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16. Abstracts <i>Volume I (PC-148248) which discusses a study</i> One of three volumes of a study which was conducted for the purpose of defining the air pollution problems of the iron foundry industry and of setting priorities for research and development activities that will lead to improved emission control capabilities at reduced cost. This volume contains a list of exhibits which are coordinated with the text in Volume I. Volume III consists of six appendices. The study includes the following basic facilities and operations: 1. raw material storage, preparation and charging, 2. Metal melting, 3. Molding, pouring and shake out, 4. Sand conditioning and reclamation, 5. Cleaning, heat treating and finishing, 6. Coremaking			
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**SYSTEMS ANALYSIS OF EMISSIONS
AND EMISSIONS CONTROL IN THE
IRON FOUNDRY INDUSTRY**

VOLUME II EXHIBITS

FEBRUARY, 1971

FOR

**Division of Process Control Engineering
Air Pollution Control Office
Environmental Protection Agency
Contract No. CPA 22-69-106**

**Prepared by
A. T. Kearney & Company, Inc.
Chicago, Illinois**

A. T. KEARNEY & COMPANY, INC.

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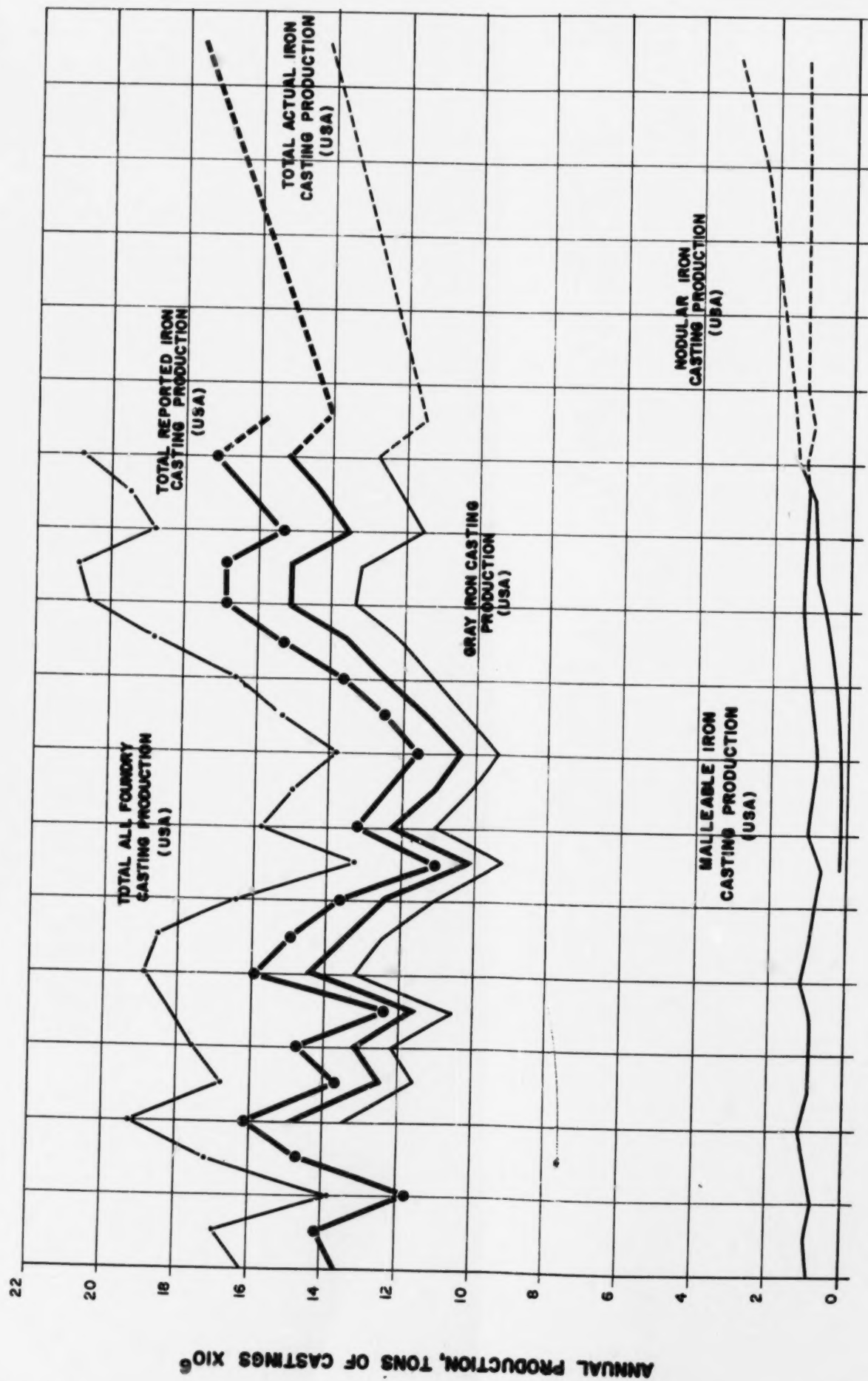
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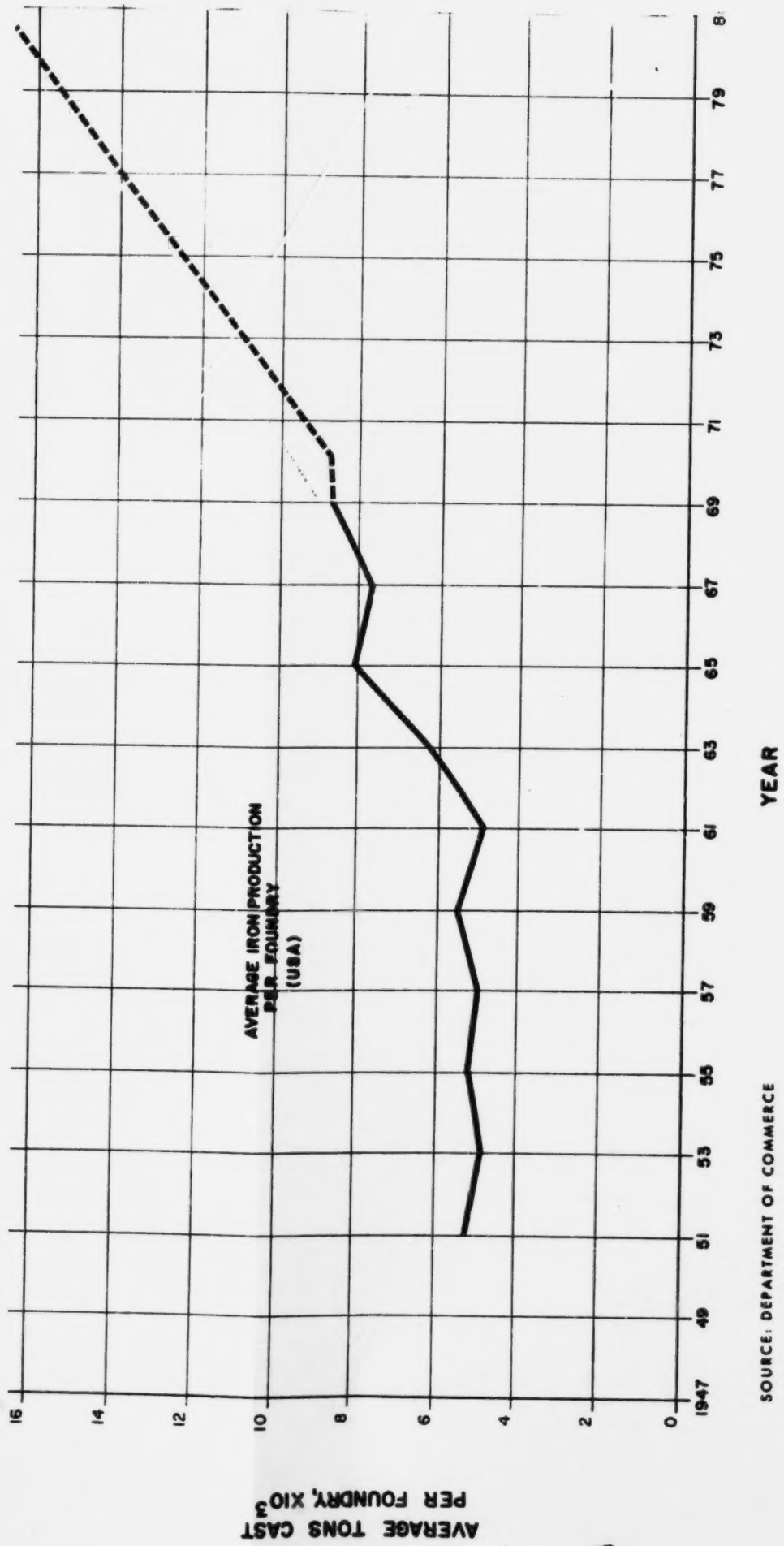
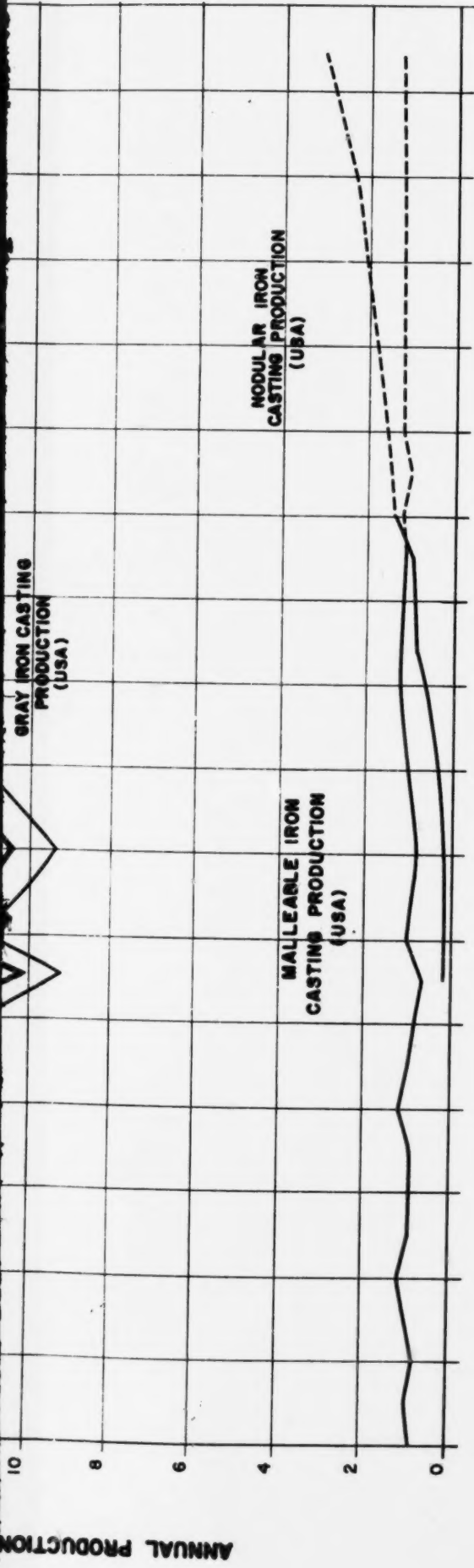
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IRON FOUNDRY PRODUCTION TRENDS



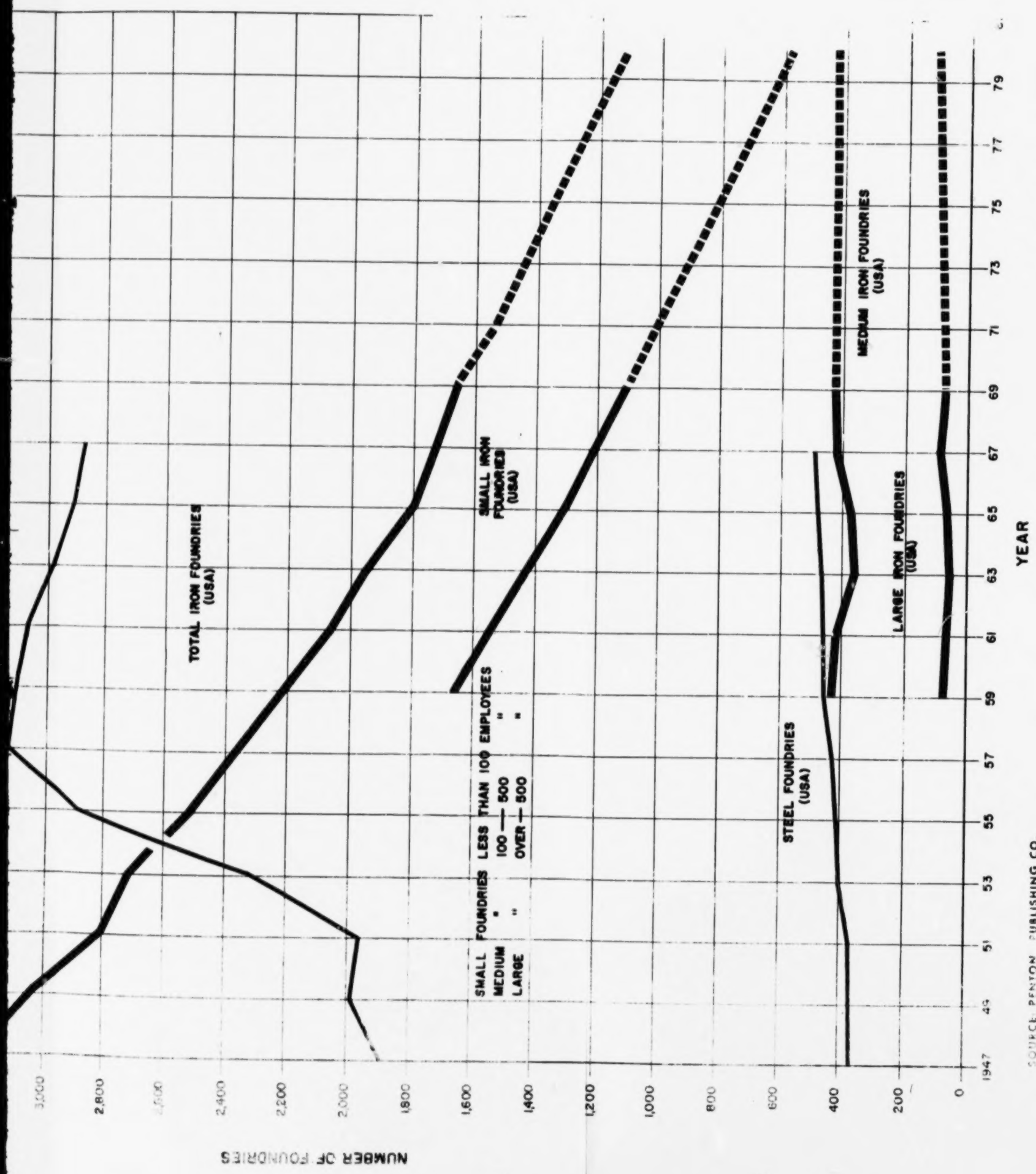
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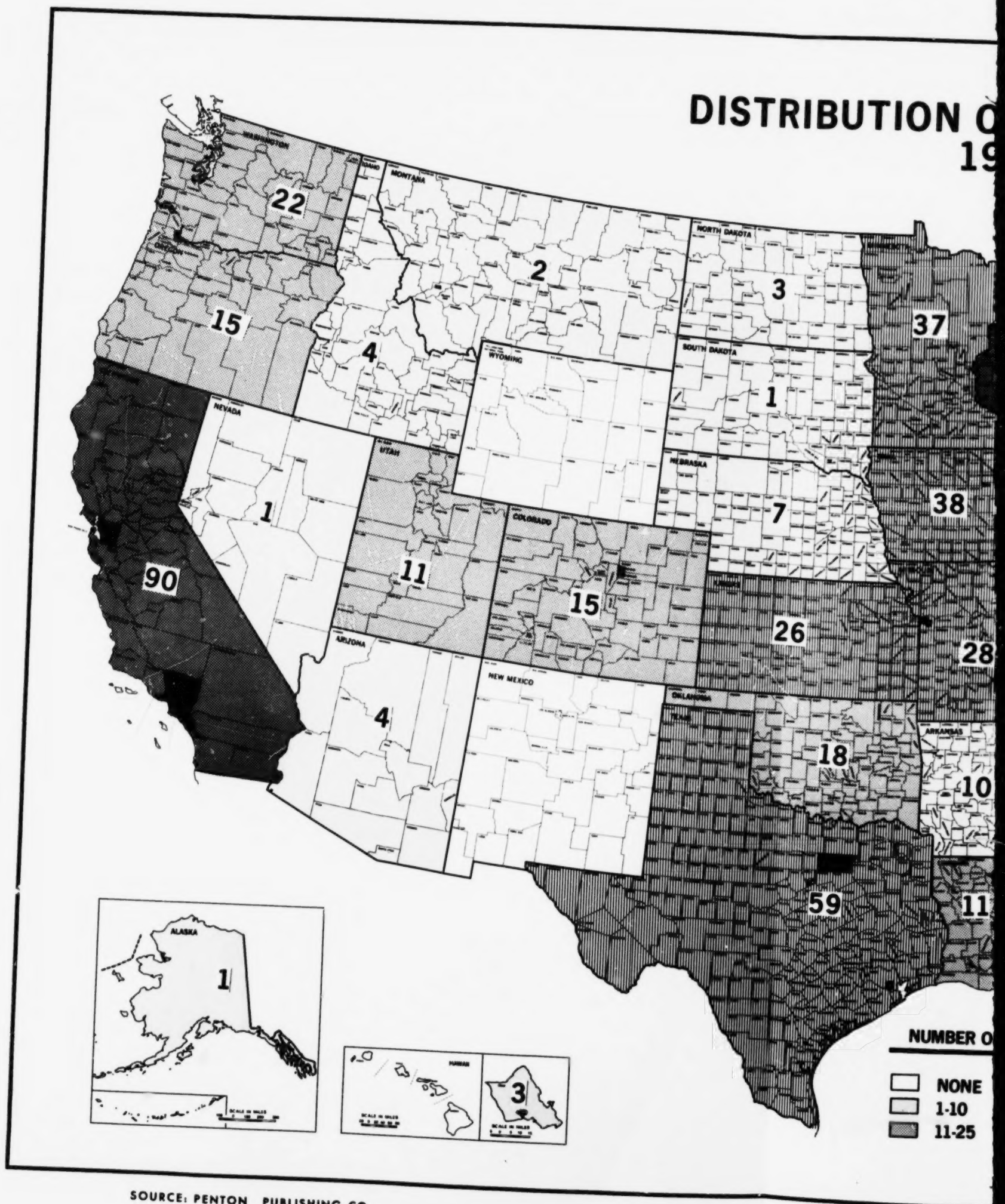
POPULATION TRENDS IN THE FOUNDRY INDUSTRY





SOURCE: PENTON PUBLISHING CO.

DISTRIBUTION OF 19



SOURCE: PENTON PUBLISHING CO.

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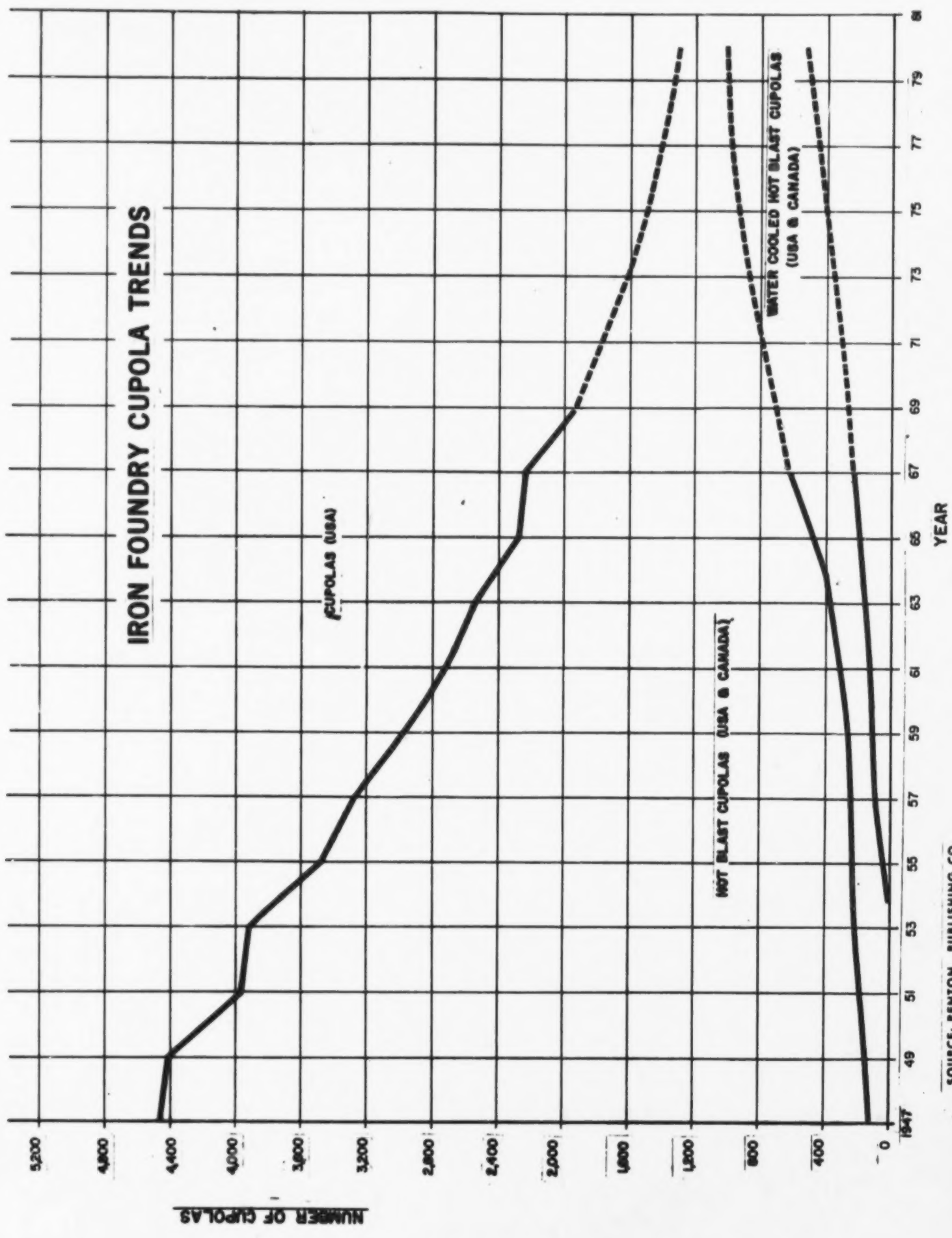
DISTRIBUTION OF IRON FOUNDRIES 1969



GEOGRAPHICAL DISTRIBUTION OF IRON FOUNDRIES

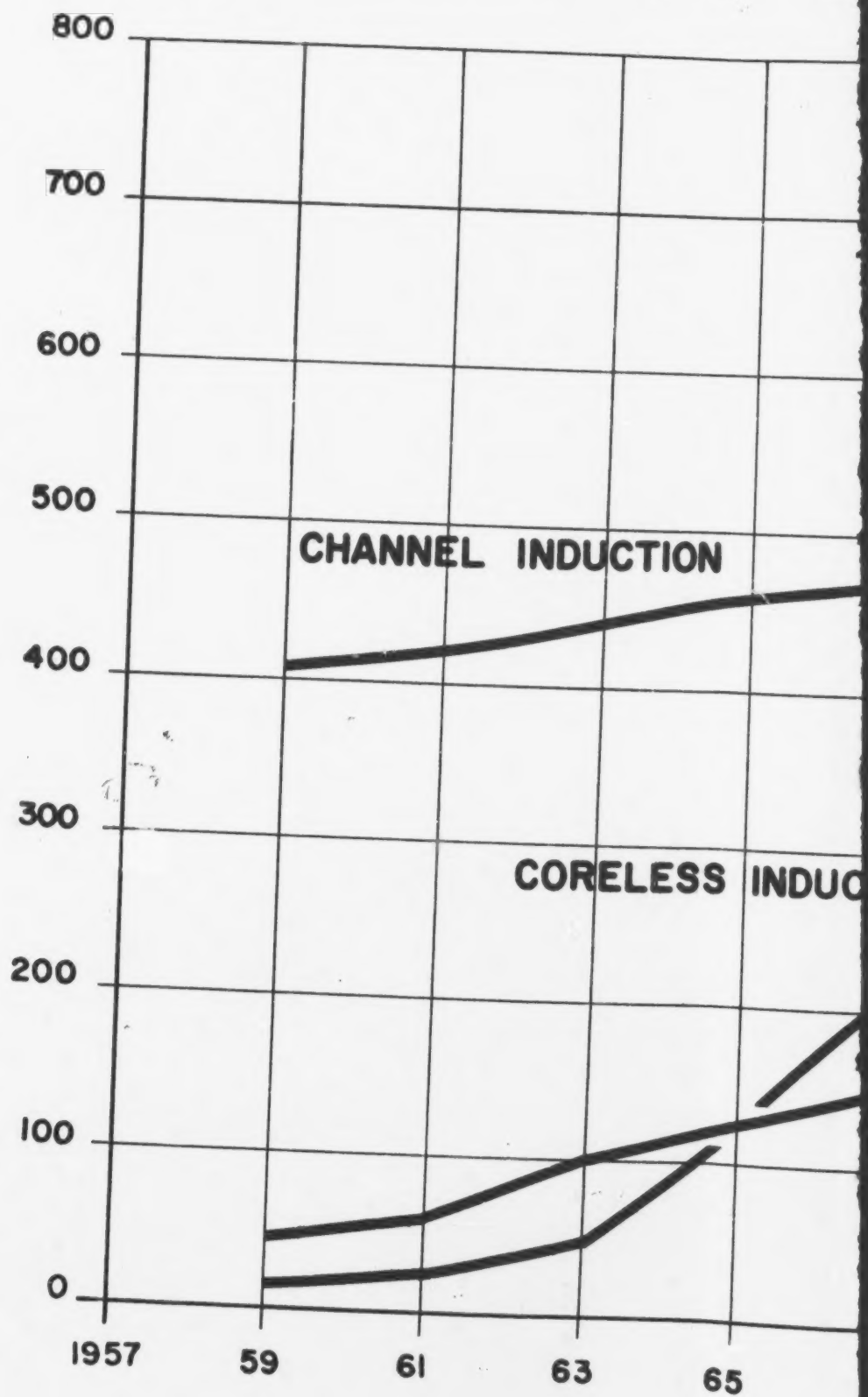
	Gray Iron		Ductile Iron		Malleable	
	1969	1965	1969	1965	1969	1965
Alabama	56	59	17	17	2	2
Alaska	1	3	-	-	-	-
Arizona	4	10	1	1	-	-
Arkansas	10	10	-	-	-	-
California	88	95	29	24	1	1
Colorado	15	18	4	3	4	4
Connecticut	24	24	7	6	5	5
Delaware	1	2	-	-	-	-
District of Columbia	-	1	-	-	-	-
Florida	17	19	3	2	-	-
Georgia	32	32	8	6	-	-
Hawaii	3	3	-	-	-	-
Idaho	4	4	-	-	-	-
Illinois	97	107	32	29	10	11
Indiana	75	75	16	12	4	4
Iowa	36	38	8	5	2	2
Kansas	24	22	9	7	-	-
Kentucky	11	15	2	2	-	-
Louisiana	10	16	2	2	-	-
Maine	8	8	1	-	-	-
Maryland	13	13	3	2	-	-
Massachusetts	53	57	13	9	3	3
Michigan	114	127	36	28	7	6
Minnesota	36	35	8	4	2	1
Mississippi	7	8	-	-	1	1
Missouri	28	29	6	3	-	-
Montana	2	2	-	-	-	-
Nebraska	7	8	1	-	-	-
Nevada	1	1	-	-	-	-
New Hampshire	8	4	-	-	-	-
New Jersey	45	48	12	10	1	1
New Mexico	-	1	-	-	1	1
New York	82	97	17	19	2	2
North Carolina	30	36	16	17	9	7
North Dakota	3	2	7	4	-	-
Ohio	151	159	61	46	16	18
Oklahoma	17	14	12	6	-	-
Oregon	13	17	5	7	-	-
Pennsylvania	155	189	48	41	16	13
Rhode Island	8	9	2	1	1	1
South Carolina	15	15	4	5	-	-
South Dakota	1	2	-	-	-	-
Tennessee	41	48	7	7	1	1
Texas	56	61	18	11	1	1
Utah	11	10	5	5	-	-
Vermont	8	8	-	-	-	-
Virginia	33	37	1	5	-	-
Washington	21	21	7	6	1	1
West Virginia	12	12	5	4	1	1
Wisconsin	54	85	28	23	10	11
Wyoming	-	-	-	-	-	-
Total United States	1,571	1,712	452	361	93	95
	1,653	1,837	387	328	104	104

Source: Foundry Magazine Census of Foundries.



IRON FOUNDRY E

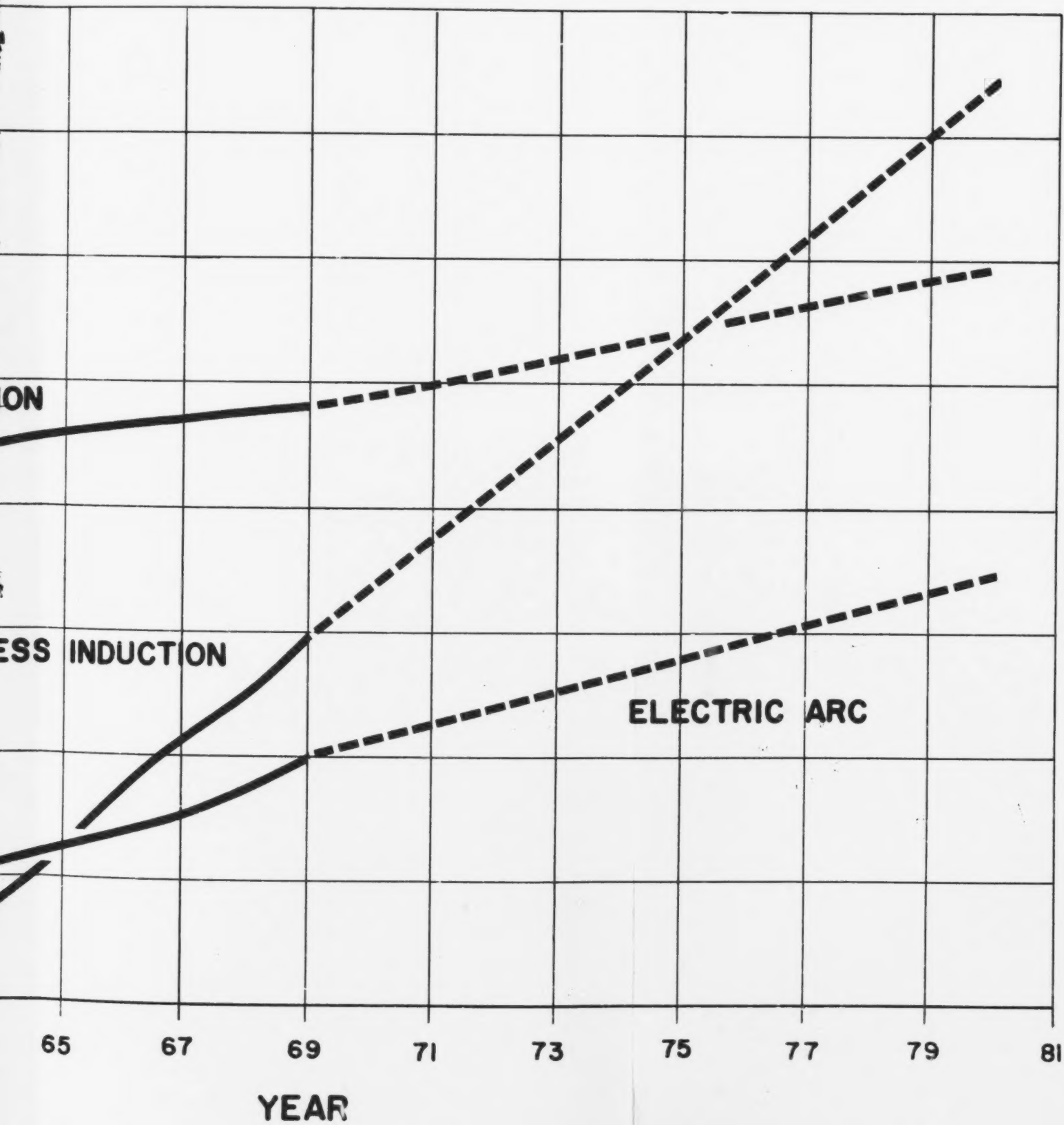
NUMBER OF FURNACES



SOURCE : DATA PROVIDED BY FURNACE MANUFACTURERS

A

DRY ELECTRIC FURNACE TRENDS



B

CHARACTERISTICS AND SOURCES
IN VARIOUS FOUNDRY

DEPARTMENT	OPERATION	TYPE
RAW MATERIAL STORAGE AND CHARGE MAKEUP	Store metal scrap, coke, limestone, dolomite, fluorspar, silica sand	Dust: Coke, limestone and
	Centrifuge or heat metal borings and turnings to remove cutting oil	Oil vapors Smoke Unburned hydrocarbons
	Weigh charge materials	Coke dust Limestone dust
MELTING	Cupola furnace melting	Fly ash, dust Coke breeze Smoke Metallic oxides Sulfur compounds Oil vapors Carbon monoxide
	Electric furnace melting	Smoke Metallic oxides Oil vapors
	Induction furnace melting	Oil vapors, metal oxides
	Reverberatory (Air) furnace	Smoke Oil vapors Metallic oxides Fly ash, sulfur compounds
	Furnace charge preheating or drying	Smoke, dust Oil vapors Metallic oxides Metallic oxides
	Holding furnaces	Iron oxide Oil vapor
	Duplexing furnaces	Oil vapor Metallic oxides
	Inoculation	Metallic oxides
	Molding	Dust, mist Vapor
MOLDING, POURING AND SHAKEOUT		

A

AND SOURCES OF EMISSIONS
FOUNDRY DEPARTMENTS

EMISSIONS			RELATIVE CONTROL- LABILITY	RELATIVE COST
TYPE	CONCENTRATION	PARTICLE SIZE (Microns)		
Dust: Coke, limestone and sand.	3 to 5gr./cu.ft. Moderate	Fine to coarse 30 to 1,000	Moderate to Difficult	Medium
Oil vapors Smoke Unburned hydrocarbons	Light Light Light	.03 to 1 .01 to .4		
Coke dust limestone dust	3 to 5gr./cu.ft. Moderate	Fine to coarse 30 to 1,000		
Fly ash, dust Coke breeze Smoke Metallic oxides Sulfur compounds Oil vapors Carbon monoxide	.2 to 5gr./cu.ft. 5gr./cu.ft. & up Heavy Moderate to heavy Light Light Heavy	8 to 20 Fine to coarse .01 to .4 To .7 .03 to 1 -	Moderate to Difficult	High
Smoke Metallic oxides Oil vapors	Heavy Moderate Heavy	.01 to .4 To .7 .03 to 1	Moderate	Medium to high
Oil vapors, metallic oxides			Easy	Little or none
Smoke Oil vapors Metallic oxides Fly ash, sulfur com- pounds	Moderate Moderate Moderate .2 to 5gr./cu.ft.	.01 to .4 .03 to 1 To .7 8 to 20	Difficult	High
Smoke, dust Oil vapors Metallic oxides Metallic oxides	Light to heavy Light to heavy 1.24#/ton .41#/ton	.01 to .4 .03 to 1 75%-5 to 60 bottom fired 0 to 20 top fired	Easy	Low
Iron oxide Oil vapor	Light Light	Fine to medium .03 to 1	Easy to moderate	Low
Oil vapor Metallic oxides	Light Light	.03 to 1 To .7	Easy	None to medium
Metallic oxides	Heavy	To 0.7	Moderate	Medium
Dust, mist Vapor	Light	Coarse	Easy	Low

B

CHARACTERISTICS AND SOURCES
IN VARIOUS FOUNDRY DEPT

DEPARTMENT	OPERATION	TYPE
MOLDING, POURING AND SHAKEOUT (Cont'd)	Pouring Gray and ductile iron Malleable	Core gases Facing fumes Metallic oxides Fluoride fumes Magnesium oxide fume Synthetic binder Smoke and fumes
	Shakeout	Dust Smoke Steam
CLEANING AND FINISHING	Abrasive cleaning	Dust
	Grinding	Metal dust Sand dust Abrasive dust Wheel bond material Vitrified resins
SAND CONDITIONING	Annealing and heat treating	Oil vapors, gas prod of combustion
	Painting	Solvent vapors
	Spray and dip	Paint spray carry-over Water spray carry-over
	New sand storage	Dust
	Sand handling system	Dust Steam
	Screening	Dust
	Mixing	Dust Flour Bentonites Sea coal Cellulose
	Drying and reclamation	Dust Core gases

A

STATISTICS AND SOURCES OF EMISSIONS
VARIOUS FOUNDRY DEPARTMENTS

EMISSIONS			RELATIVE CONTROL- LABILITY	RELATIVE COST
TYPE	CONCENTRATION	PARTICLE SIZE (Microns)		
Core gases	Heavy		Moderate	Medium
Facing fumes	Heavy			
Metallic oxides	Light	Fine to medium		
Fluoride fumes	Heavy			
Magnesium oxide fumes	Heavy	.01 to .4		
Synthetic binder	Moderate to heavy			
Smoke and fumes				
Dust	3 to 5gr./cu.ft.	50%-2 to 15	Moderate	Medium
Smoke	Heavy	.01 to .4		
Steam	Heavy			
Dust	3gr./cu.ft. & up	50%-2 to 15	Easy	Low
Metal dust	5gr./cu.ft. & up	Above 7	Medium	Low
and dust	3 to 5gr./cu.ft.	Fine to medium		
abrasive dust	.5 to 2gr./cu.ft.	50%-2 to 7		
Wheel bond material	Light	Fine		
Nitrified resins	Light	50%-2 to 15		
Oil vapors, gas products of combustion		.03 to 1	Moderate	Low
Solvent vapors			Easy	Low
Paint spray carry-over	.5 to 2gr./cu.ft.	50%-2 to 7		
Water spray carry-over				
Dust	3 to 5gr./cu.ft.	50%-2 to 15	Moderate	High
Dust	3 to 5gr./cu.ft.	50%-2 to 15	Moderate	Medium
Steam				
Dust	3 to 5gr./cu.ft.	50%-2 to 15	Easy	Low
Dust	3 to 5gr./cu.ft.	50%-2 to 15	Easy	Medium
Flour	Moderate	Fine to medium		
Bentonites	Moderate	Fine to medium		
Sea coal	Moderate	Fine to medium		
Cellulose	Moderate	Fine to medium		
Dust	1/2 to 2gr./cu.ft.	50%-7 to 15	Easy	Medium
Core gases		.03 to 1		

B

CHARACTERISTICS AND S
IN VARIOUS FOUND

DEPARTMENT	OPERATION	TYPE
COREMAKING	Sand storage	Dust Flour Binders
	Coremaking	Resin dust Sand dust
	Baking	Vapors, gases Smoke

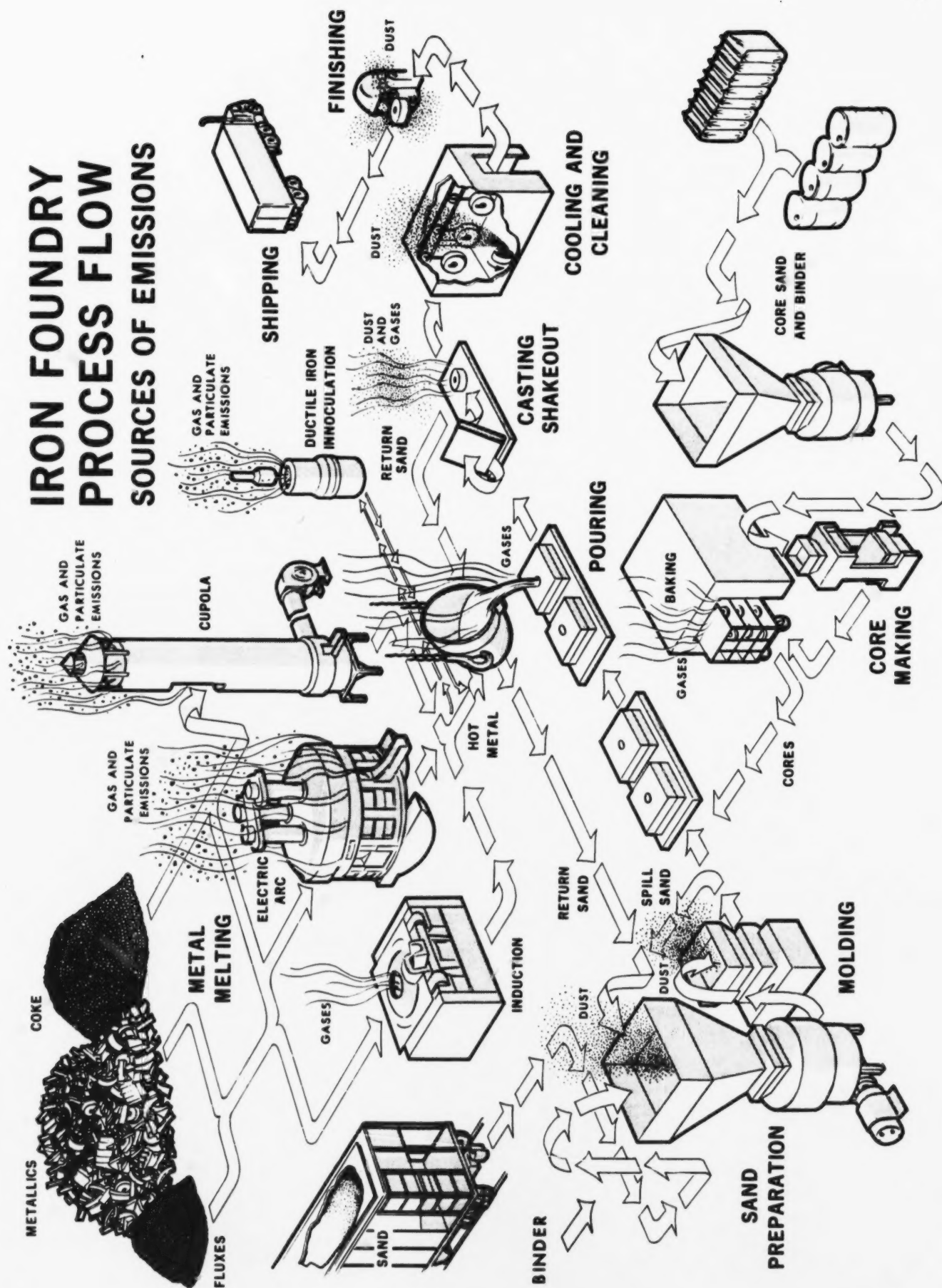
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CHARACTERISTICS AND SOURCES OF EMISSIONS
IN VARIOUS FOUNDRY DEPARTMENTS

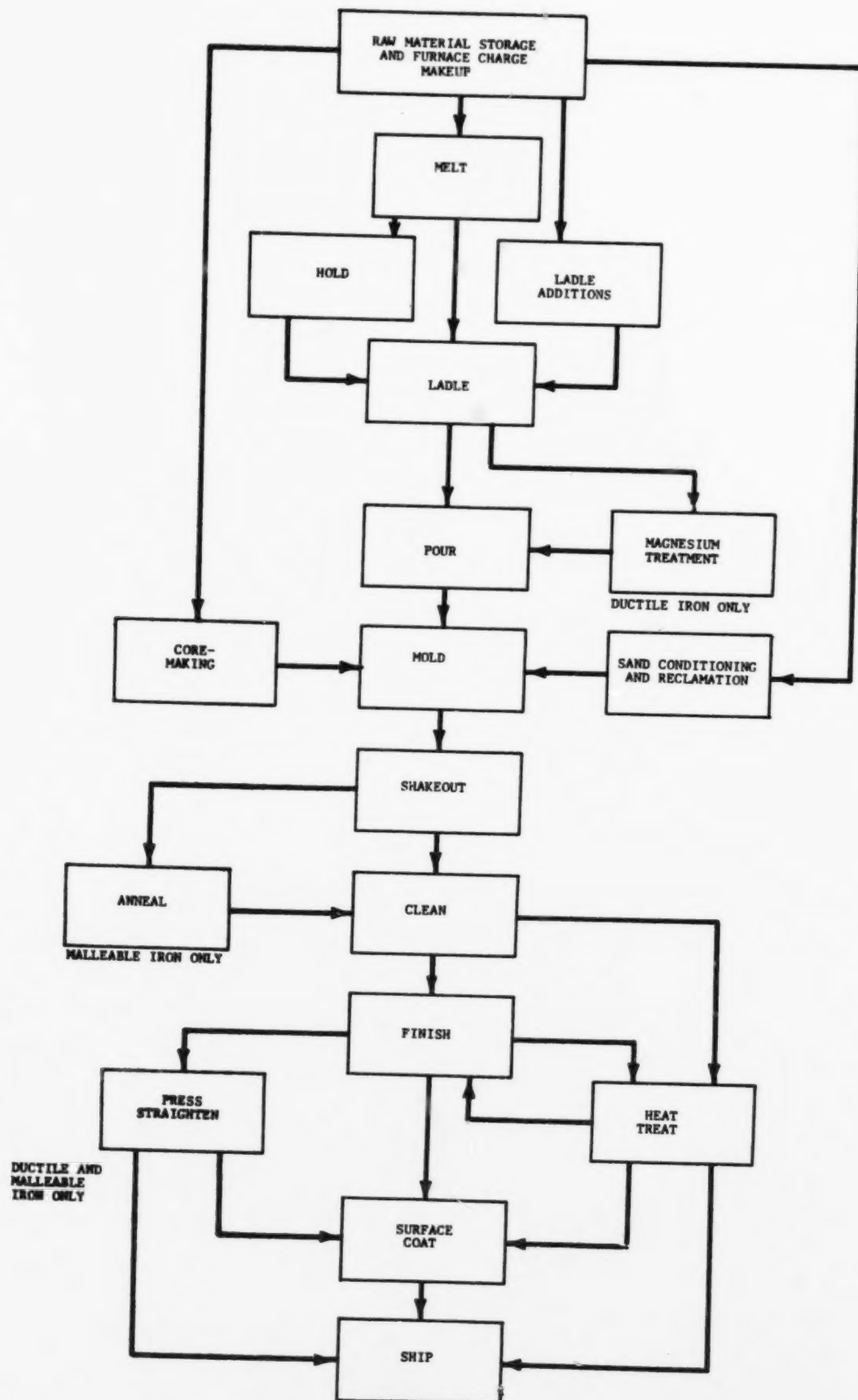
TYPE	EMISSIONS		RELATIVE CONTROL- LABILITY	RELATIVE COST
	CONCENTRATION	PARTICLE SIZE (Microns)		
Dust Flour Binders	Heavy 3 to 5gr./cu.ft.	Fine 50%-7 to 15	Moderate	High
Resin dust Sand dust	Heavy Light	Fine to medium Fine to medium	Moderate	Medium
Vapors, gases Smoke	-	-	Easy	Medium

B

IRON FOUNDRY PROCESS FLOW SOURCES OF EMISSIONS



PROCESS FLOW DIAGRAM
GRAY, DUCTILE AND MALLEABLE IRON



NOTE: ALL OPERATIONS APPLY TO GRAY, DUCTILE AND MALLEABLE IRON UNLESS OTHERWISE NOTED.

SUMMARY OF GRAY IRON SPECIFICATIONS

Specifying Body	Specifying Number	Class	Tensile Strength Minimum PSI	Brinell Hardness		Total Carbon Percent		Silicon Percent	
				Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
American Society for Testing and Materials	A159-62T	G2000(110)	20,000	-	187	3.40	3.70	2.30	2.80
		G3000(111)	30,000	170	223	3.20	3.50	2.00	2.30
		G3000a(113)	30,000	179	229	3.40	-	1.10	2.10
		G4000b(114)	40,000	207	269	3.40	-	1.10	1.80
Society of Automotive Engineers	J431a	G3500c(115)	35,000	187	241	3.50	-	1.10	1.80
		G3500(120)	35,000	187	241	3.10	3.40	1.90	2.20
		G4000(121)	40,000	202	255	3.00	3.30	1.80	2.10
		G4500(122)	45,000	217	269	3.00	3.30	1.80	2.10
General Services Administration	QQ-1-653	G4000d(123A)	40,000	248	311	3.10	3.40	2.10	2.40
		G4000e(123B)	40,000	248	311	3.10	3.45	2.10	2.40
		G4000f(123C)	40,000	248	311	3.40	3.75	2.10	2.35

Source: Gray and Ductile Iron Founders' Society, Inc.

SUMMARY OF DUCTILE IRON SPECIFICATIONS

Specifying Body and Number	Use	Class or Grade	Tensile Strength Minimum PSI	Yield Strength Minimum PSI	Total Carbon		Silicon		Manganese		Phosphorus		Nickel		Chromium		Brinell Hardness	
					Percent Min.	Max.	Percent Min.	Max.	Percent Min.	Max.	Percent Min.	Max.	Percent Min.	Max.	Percent Min.	Max.	Min.	Max.
American Society for Testing and Materials A439-62	Austenitic Ductile Iron Castings	D-2	58,000	30,000	-	3.00	1.50	3.00	.70	1.25	-	.08	18.00	22.00	1.75	2.75	139	202
		D-2B	58,000	30,000	-	3.00	1.50	3.00	.70	1.25	-	.08	18.00	22.00	2.75	4.00	148	211
		D-2C	58,000	28,000	-	2.90	1.00	3.00	1.80	2.40	-	.08	21.00	24.00	-	.50	121	171
		D-3	55,000	30,000	-	2.60	1.00	2.80	-	1.00	-	.08	28.00	32.00	2.50	3.50	139	202
		D-3A	55,000	30,000	-	2.60	1.00	2.80	-	1.00	-	.08	28.00	32.00	1.00	1.50	131	193
		D-4	60,000	-	-	2.60	5.00	6.00	-	1.00	-	.08	28.00	32.00	4.50	5.50	202	273
American Society for Testing and Materials A445-63T	Ferritic Ductile Iron Castings for Valves, Flanges, Pipe Flanges, Pipe Fittings and Other Piping Components	D-5	55,000	30,000	-	2.40	1.00	2.80	-	1.00	-	.08	34.00	36.00	-	.10	131	185
		D-5B	55,000	30,000	-	2.40	1.00	2.80	-	1.00	-	.08	34.00	36.00	2.00	3.00	139	193
		60-45-15	60,000	45,000	3.00	-	-	2.50	-	-	-	.08	-	-	-	-	149	201

Source: Gray and Ductile Iron Founders' Society, Inc.

SUMMARY OF MALLEABLE IRON SPECIFICATIONS

TYPICAL COMPOSITION RANGES

Type	Grade	Carbon Percent		Silicon Percent		Manganese Percent		Sulfur Percent		Phosphorus Percent	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Ferritic Malleable Iron	32510	2.30	2.65	.90	1.65	.25	.55	.05	.18	-	.18
	35018	2.00	2.45	.95	1.35	.25	.55	.05	.18	-	.18
Pearlitic Malleable Iron	-	2.00	2.65	.90	1.65	.25	1.25	.05	.18	-	.18

Source: American Society for Metals
Handbook, Vol. 1, 1961.

IRON FOUNDRY SCRAP SPECIFICATIONS

EXHIBIT IV-6

Source	Carbon Percent	Silicon Percent	Sulfur Percent	Phosphorus Percent	Manganese Percent
Agricultural and Stove Scrap	3.25 - 3.60	2.35 - 2.55	.08 - .13	.50 - .70	.50 - .70
Soil Pipe	3.25 - 3.60	2.35 - 2.50	.12 Max.	.65 - .90	.50 - .70
Automotive Blocks	3.10 - 3.45	2.10 - 2.50	.12 Max.	.15 - .30	.50 - .70
Malleable Iron	2.25 - 2.65	1.20 Max.	.05 Max.	.05 Max.	.40 Max.
Machinery Castings Light	3.35 - 3.55	2.25 - 2.55	.10 Max.	.20 Max.	.55 - .70
Medium	3.25 - 3.45	2.20 - 2.25	.12 Max.	.12 - .18	.55 - .70
Heavy	3.15 - 3.30	1.80 - 2.10	.12 Max.	.12 - .20	.65 - .75
Cast Iron Car Wheels	3.40 - 3.60	.60 - .80	.09 - .15	.15 - .25	.55 - .65
Ductile Iron	3.35 - 3.55	2.25 - 2.55	.04 Max.	.08 Max.	.50 Max.

Source: Adapted from "Maximum Limits for Specified Elements in Foundry Grade Scrap."
Data collected by American Foundrymen's Society.

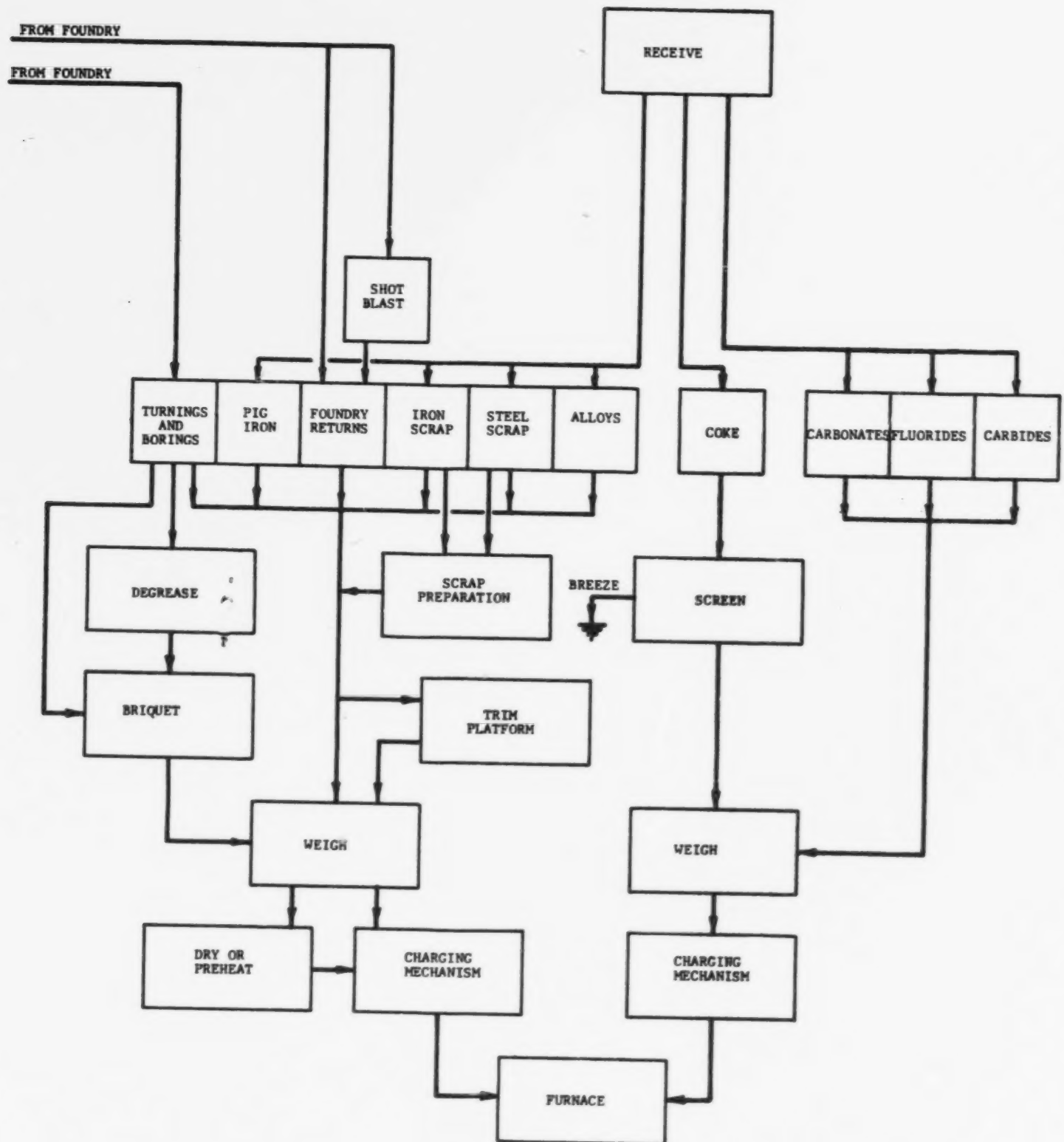
FIG IRON AND FERROALLOY SPECIFICATIONS

Designation	Silicon Percent	Sulfur Max. Percent	Phosphorus Percent	Manganese Percent	Carbon Percent
F1 - Foundry, low Phosphorus	1.75 - 3.50	.05	.30 - .50	.50 - 1.25	-
Fh - Foundry, high phosphorus	1.75 - 3.50	.05	.501 - .700	.50 - 1.25	-
Fs - Foundry, Southern	1.75 - 3.50	.05	.70 - .90	.40 - .75	-
S - Silvery	5.0 - 17.0	.05	.30 Max.	1.0 - 2.00 Max.	-
Ferromanganese	1.25 Max.	.05	.10 - .35 Max.	.78 - .85	Up to 7.50
Ferrophosphorus	1.50 - 1.75	.05	17.0 - 25.0 Max.	.07 - .50	1.1 - 2.0
Spiegeleisen	1.0 Max.	.05	.25 Max.	16.0 - 28.0	6.5 Max.
Ferrosilicon	8.0 - 18.0	.04 - .06	.05 - .15	-	.15 - 1.50

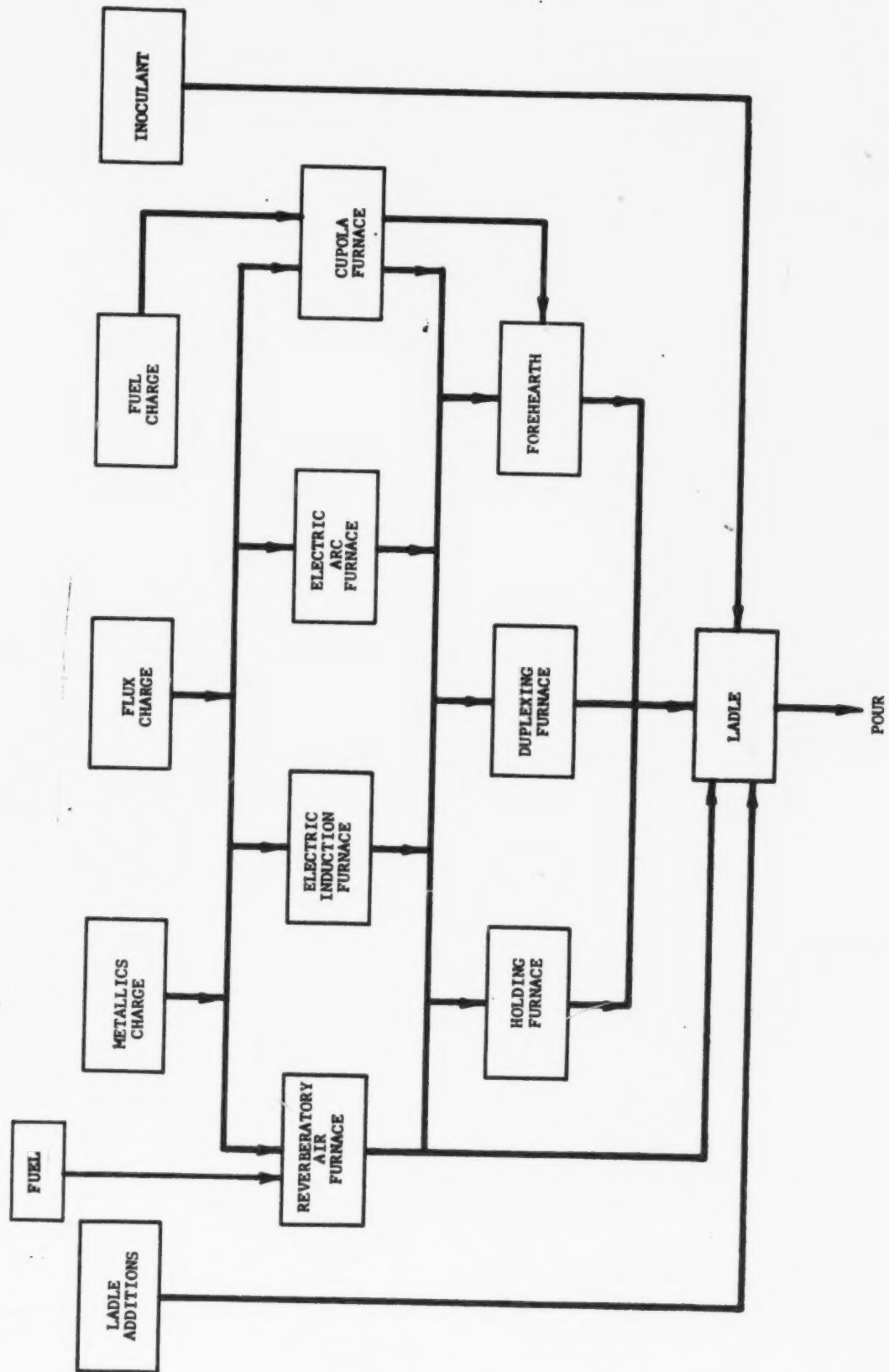
Source: The Modern Blast Furnace, Iron and Steel Engineers, April, 1946.

PROCESS FLOW DIAGRAM
RAW MATERIAL STORAGE AND
FURNACE CHARGE MAKEUP

EXHIBIT IV-8

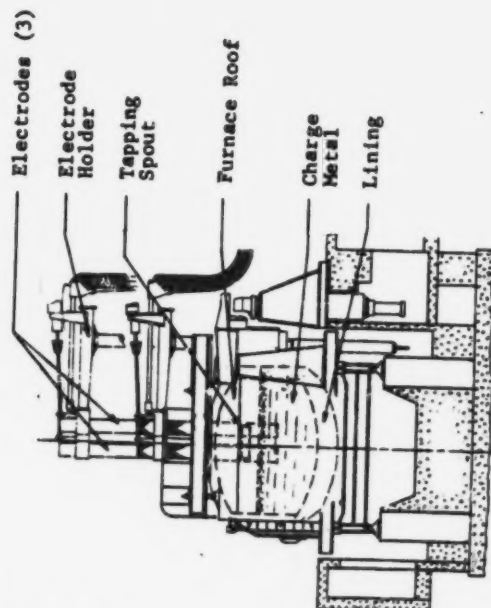


PROCESS FLOW DIAGRAM
MELTING DEPARTMENT

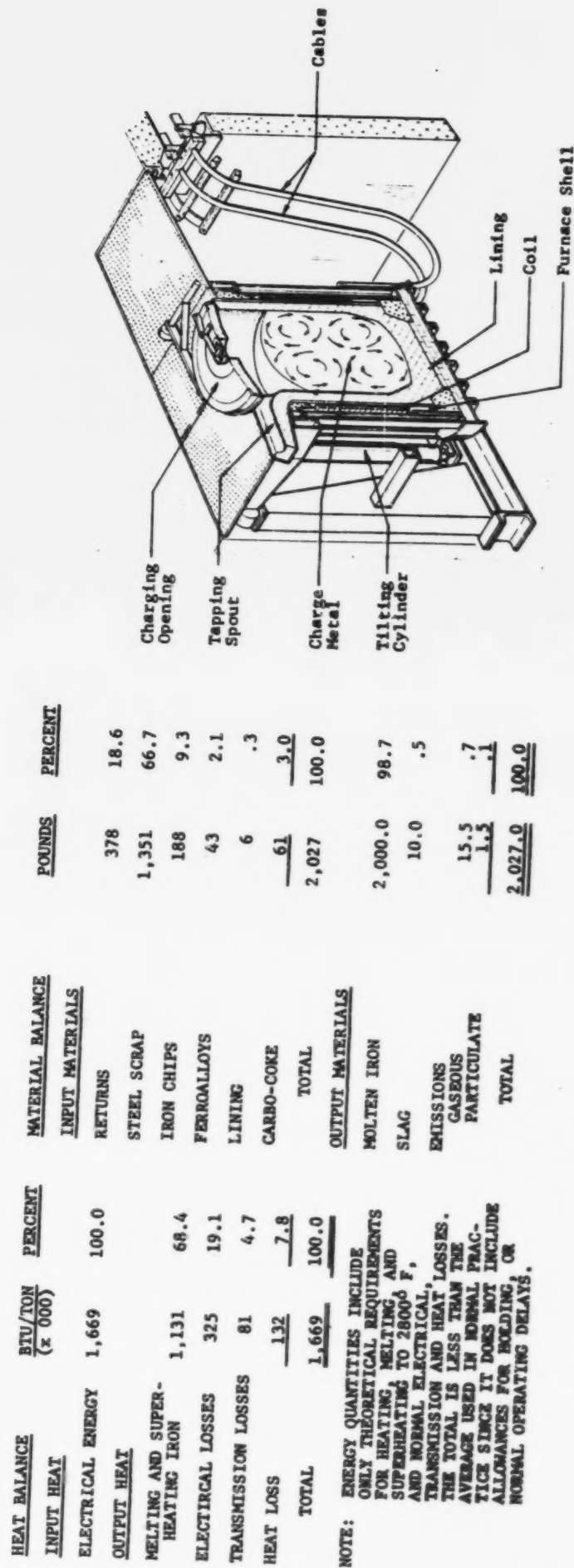


<u>HEAT BALANCE</u>		<u>BTU/Ton (x1000)</u>	<u>Percent</u>	<u>MATERIAL BALANCE</u>		
<u>Input Heat</u>				<u>Input Material</u>	<u>Pounds</u>	<u>Percent</u>
Electrical Energy	1,907	100.0	Returns	1,388	56.9	
			Steel Scrap	630	25.8	
			Ferroalloys	17	1.7	
			Carbo-Coke	31	1.3	
			Electrodes	10	.4	
			Air	318	13.0	
			Moisture	8	.3	
			Lining	38	1.6	
			Total	2,440	100.0	
				<u>Output Material</u>		
				Molten Iron	1,997	81.8
				Slag	93	3.8
				Particulate Emissions	14	.6
				Gaseous Emissions	336	13.8
				Total	2,440	100.0

NOTE: Energy quantities include only theoretical requirements for heating, melting, and superheating to 2800° F, and normal electrical, transmission and heat losses. The total is less than the average used in normal practice since it does not include allowances for holding, or normal operating delays.

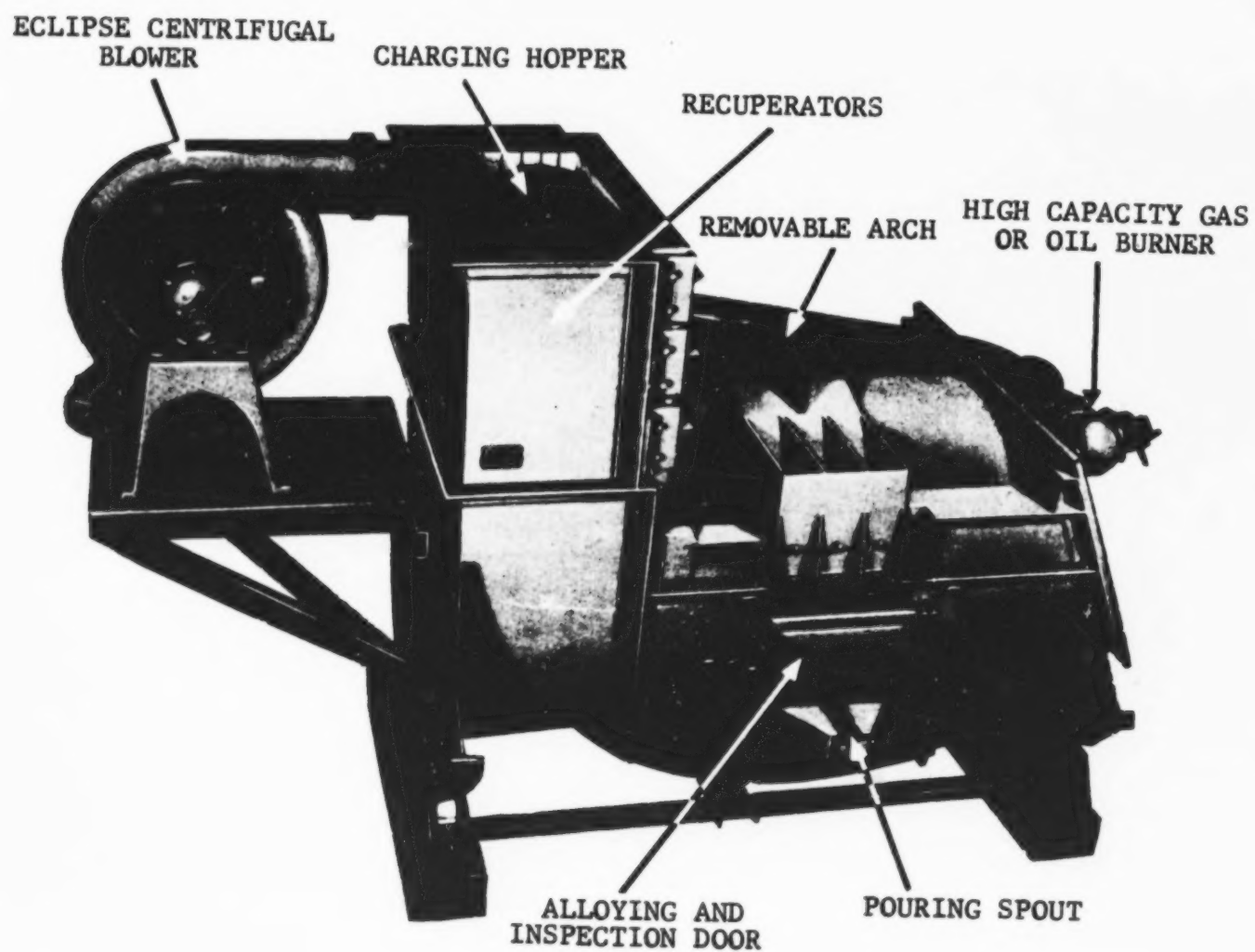


ELECTRIC ARC FURNACE - HEAT AND MATERIAL BALANCE

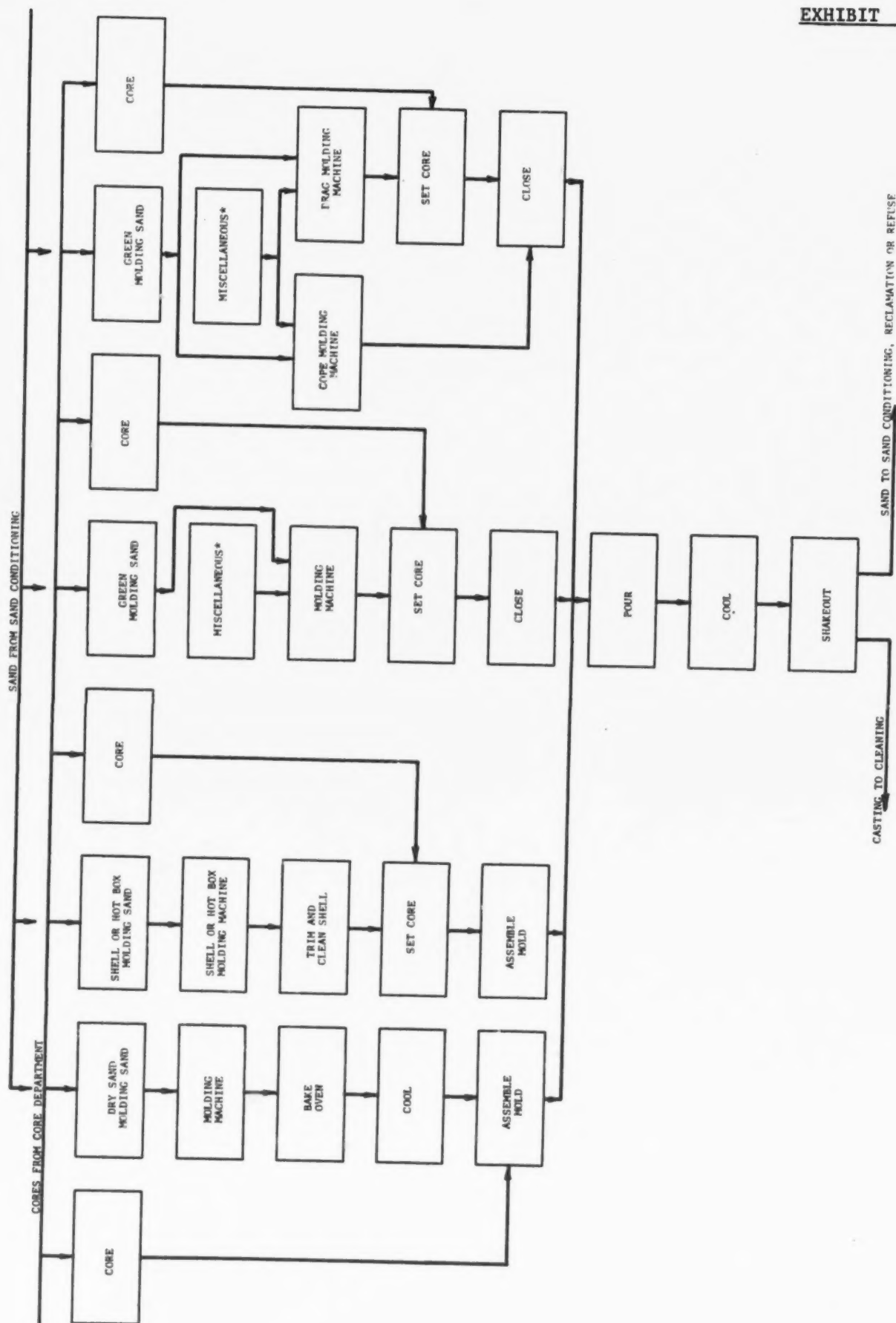


CORELESS INDUCTION FURNACE - HEAT AND MATERIAL BALANCE

ILLUSTRATION OF REVERBERATORY FURNACE

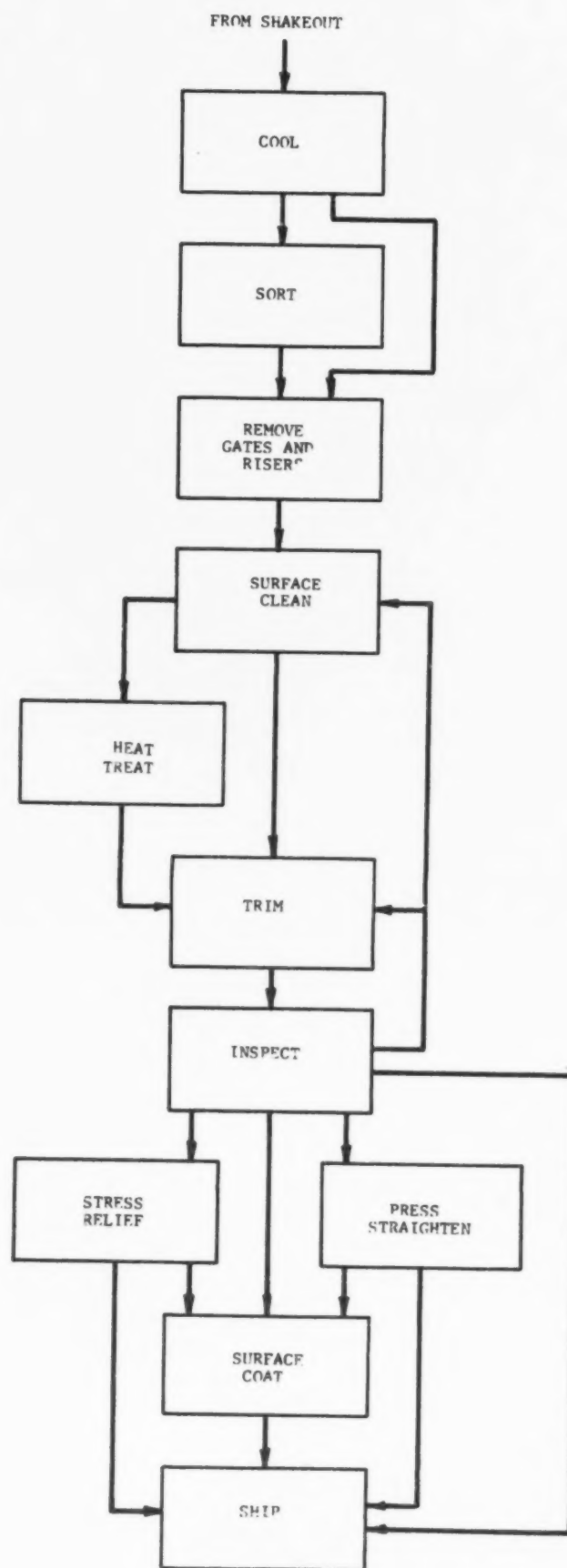


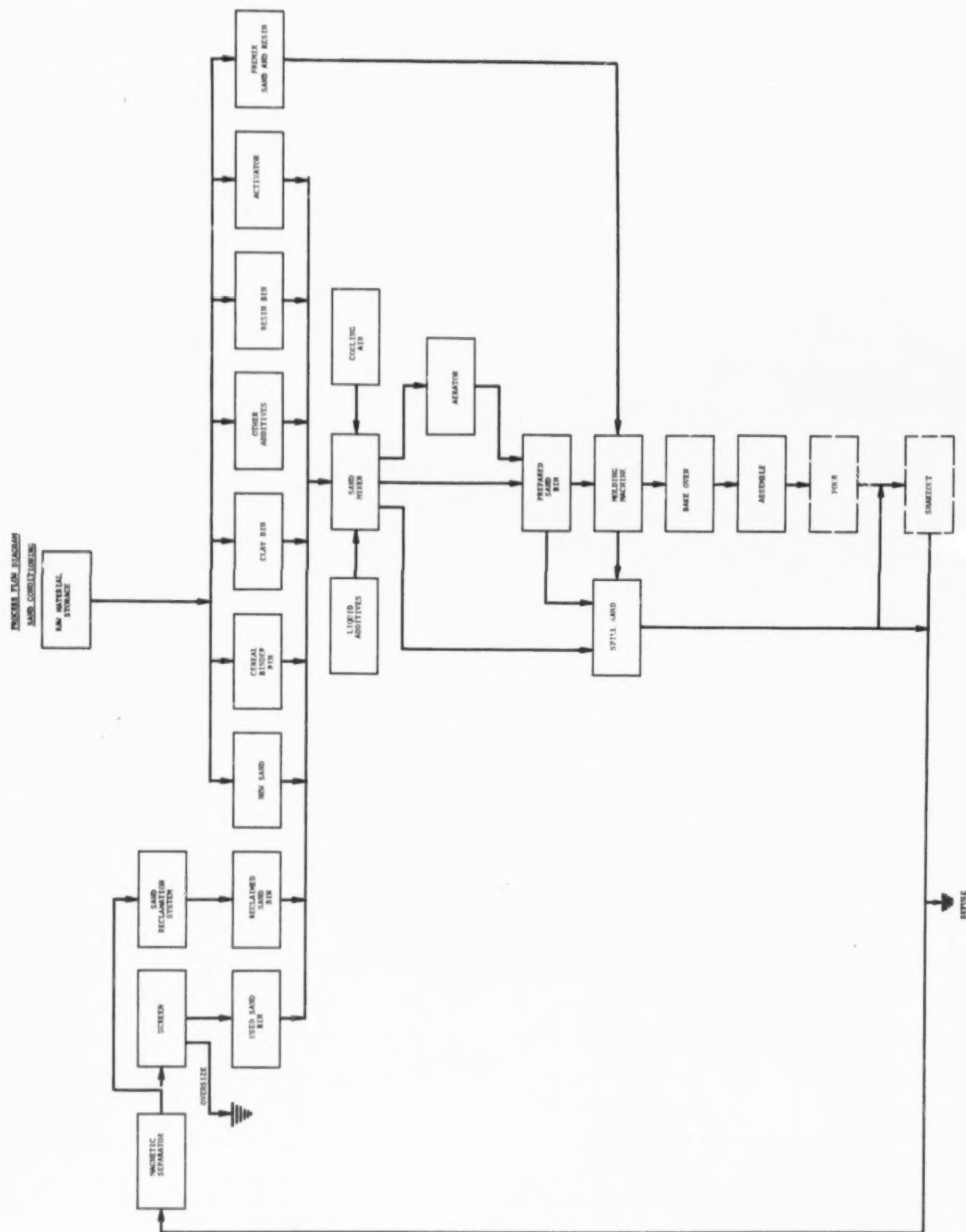
Source: The Wheelabrator Corporation.



* MISCELLANEOUS - PARTING COMPOUND, WASH, CHAPLETS, ETC.

PROCESS FLOW DIAGRAM
CLEANING & FINISHING





PROCESS FLOW DIAGRAM

CORE MAKING

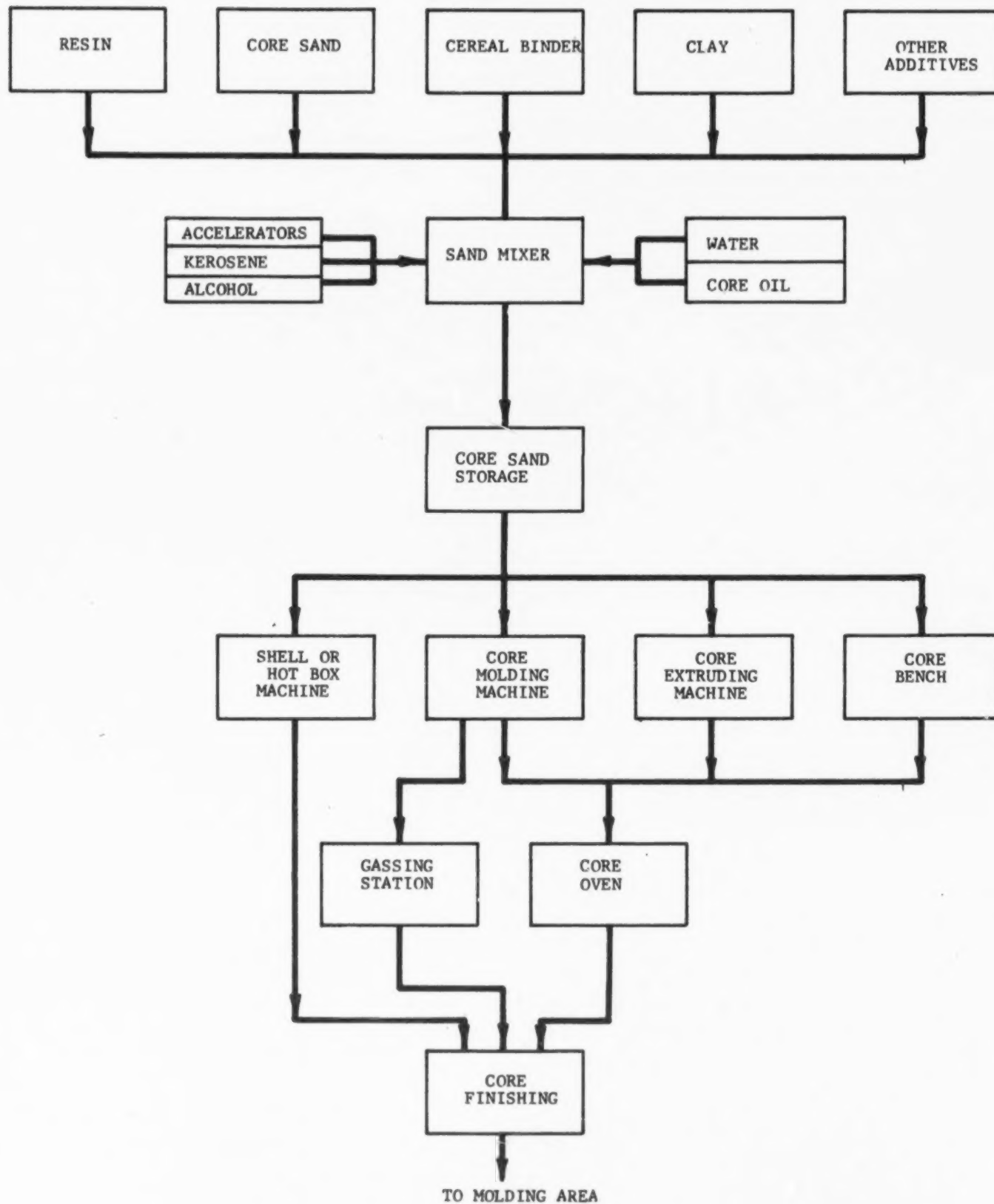
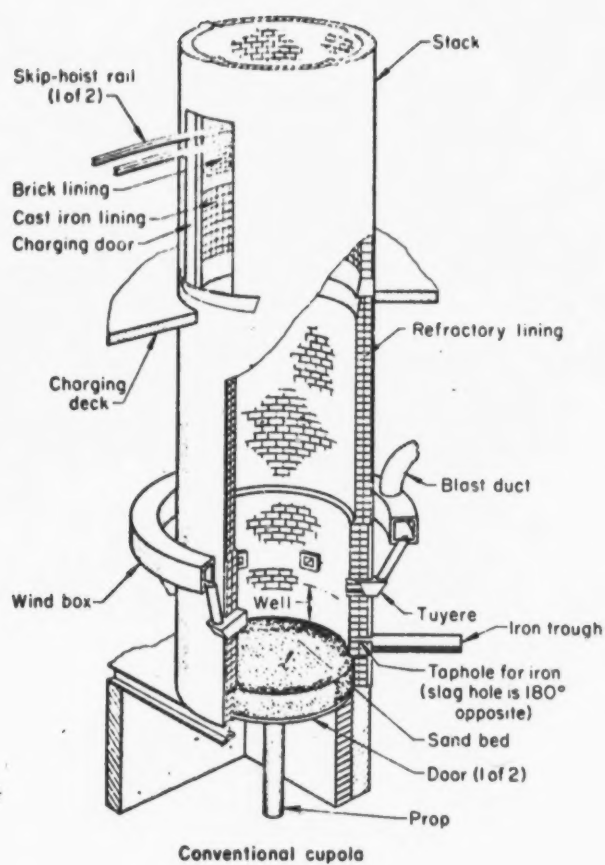
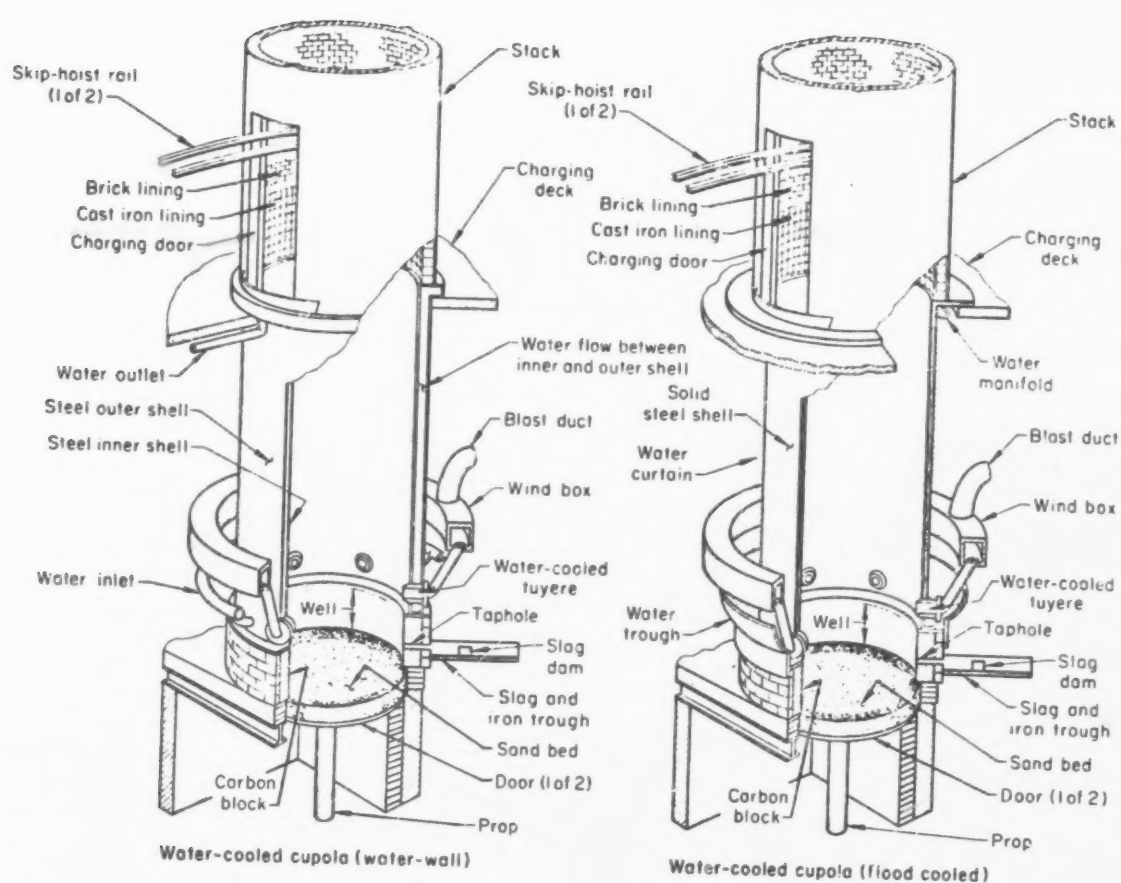


ILLUSTRATION OF CONVENTIONAL LINED CUPOLA



Source: Metals Handbook, 8th Edition, Vol. 5,
Forging and Casting, American Society
for Metals, 1970, p. 337.

ILLUSTRATION OF WATER-COOLED CUPOLA



Source: Metals Handbook, 8th Edition, Vol. 5, Forging and Casting, American Society for Metals, 1970, p. 337.

ILLUSTRATION OF CUPOLA REACTION AREA

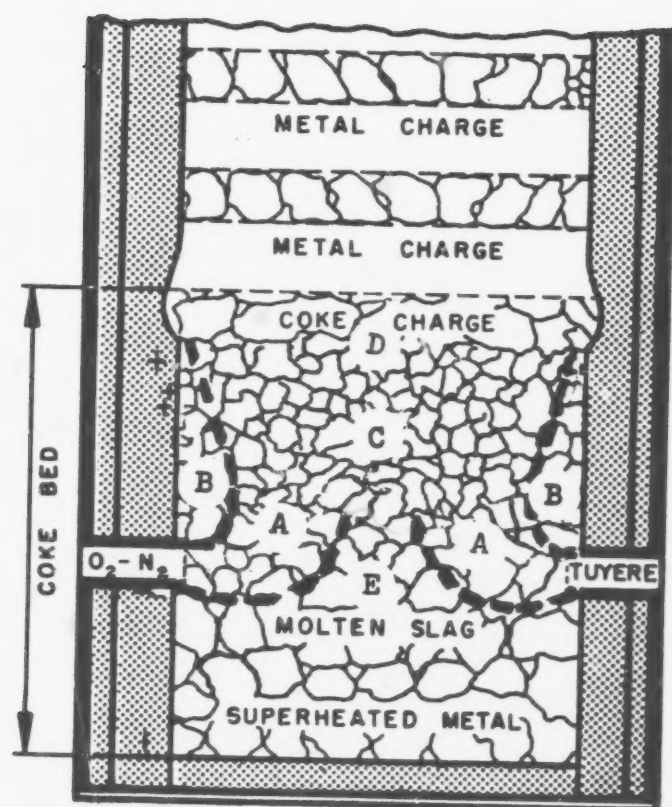
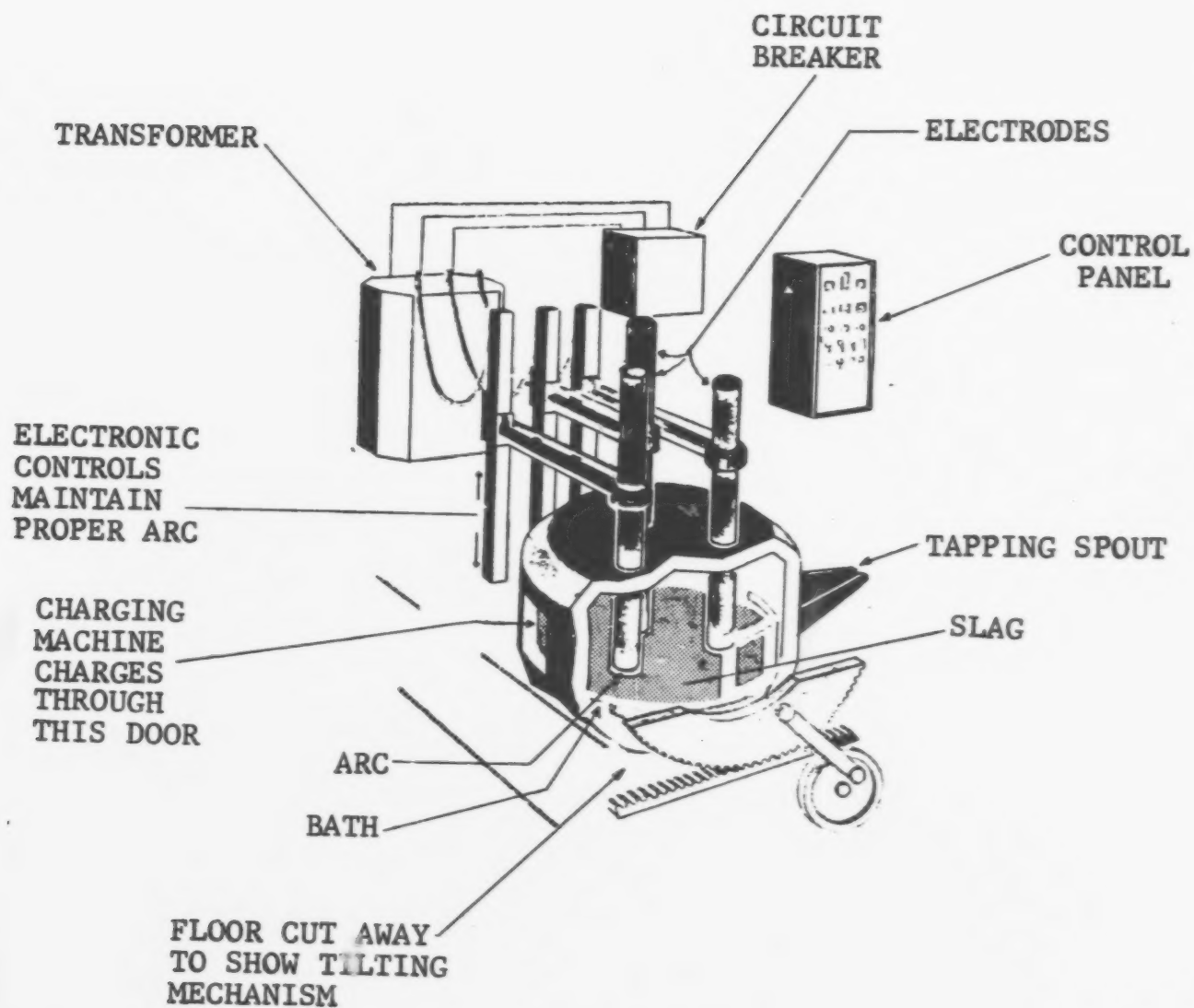


Fig. 3.3. Cross-section of cupola showing reaction areas.
 A — $O_2 + CO_2$ D — High $CO: CO_2$ ratio
 B — Area high in O_2 E — High $CO: CO_2$ ratio
 C — $CO + CO_2$

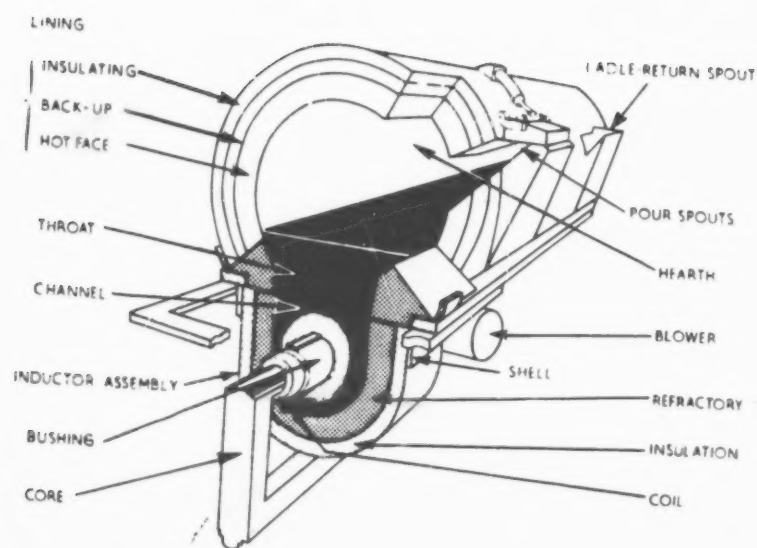
Source: The Cupola and Its Operation;
 published by the American
 Foundrymen's Society, Third
 Edition, 1965, p. 26.

ILLUSTRATION OF ELECTRIC ARC FURNACE



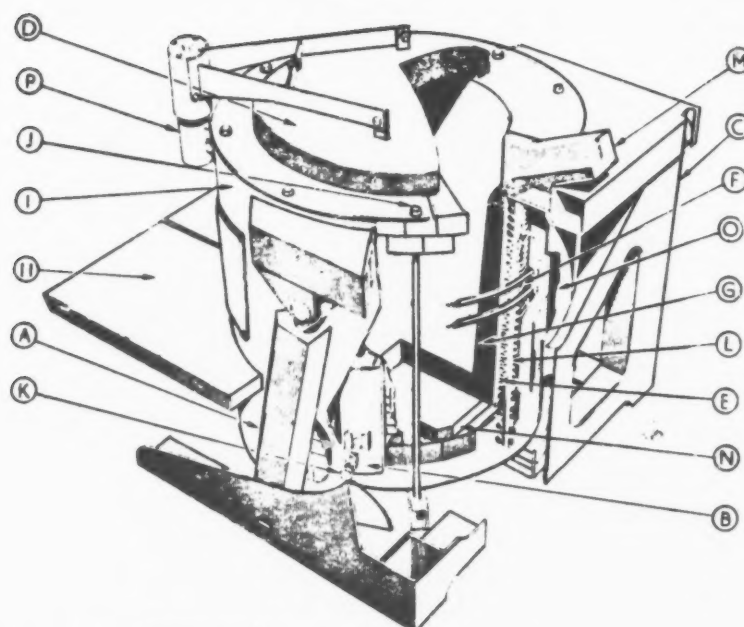
Source: The Picture Story of Steel,
published by the American Iron
and Steel Institute, 1952,
p. 18.

ILLUSTRATION OF CHANNEL INDUCTION FURNACE



Source: "Electric Melting for Mass Production
in U.S. Iron Foundries "
Modern Casting, July, 1968, p. 47.

ILLUSTRATION OF CORELESS INDUCTION FURNACE

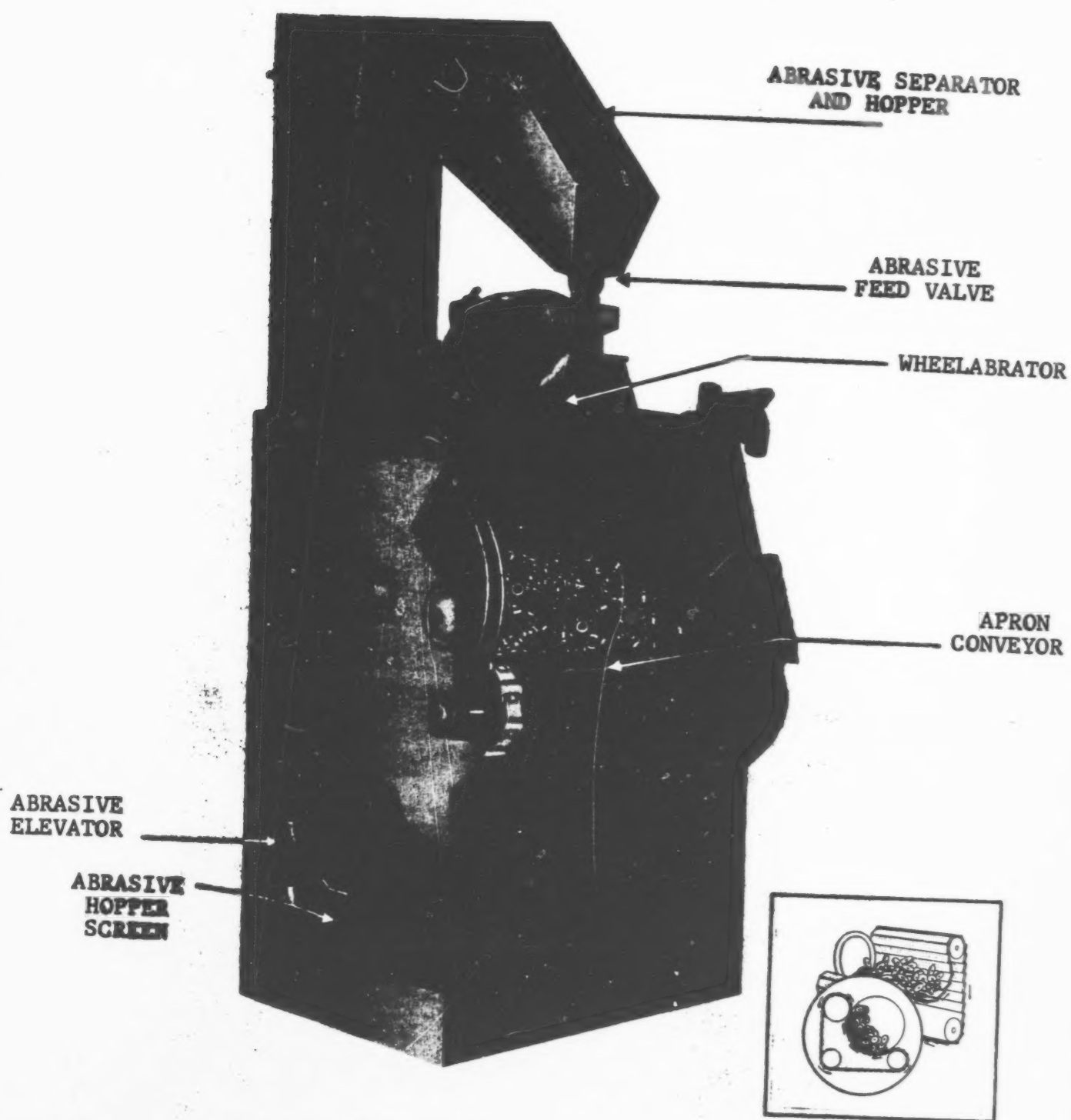


A. HYDRAULIC TILT CYLINDERS
 B. SHUNTS
 C. STANCHION
 D. COVER
 E. COIL
 F. LEADS
 G. WORKING REFRACTORY
 H. OPERATOR'S PLATFORM

I. STEEL SHELL
 J. TIE RODS
 K. CLAMPING BOLTS
 L. COIL SUPPORT
 M. SPOUT
 N. REFRACTORY BRICK
 O. ACCESS PORT
 P. LID HOIST MECHANISM

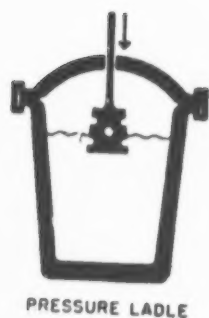
Source: "Electric Melting for Mass Production
 in U.S. Iron Foundries,"
 Modern Casting, July, 1968, p. 47.

ILLUSTRATION OF REVERBERATORY FURNACE

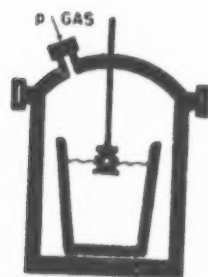


Source: Eclipse Fuel Engineering Company.

ILLUSTRATION OF MAGNESIUM TREATMENT METHODS
FOR PRODUCING DUCTILE IRON



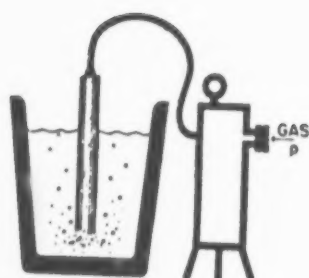
PRESSURE LADLE



PRESSURE CHAMBER



DETACHABLE BOTTOM LADLE
(MAG-COKE)



INJECTION



TRICKLING-IN (GAZAL)



PLUNGING



POUR-OVER



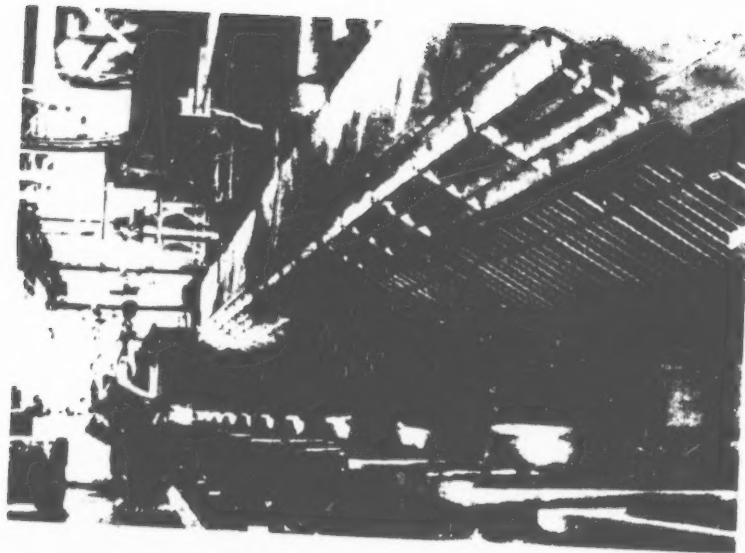
THROW-IN



PLUNGING

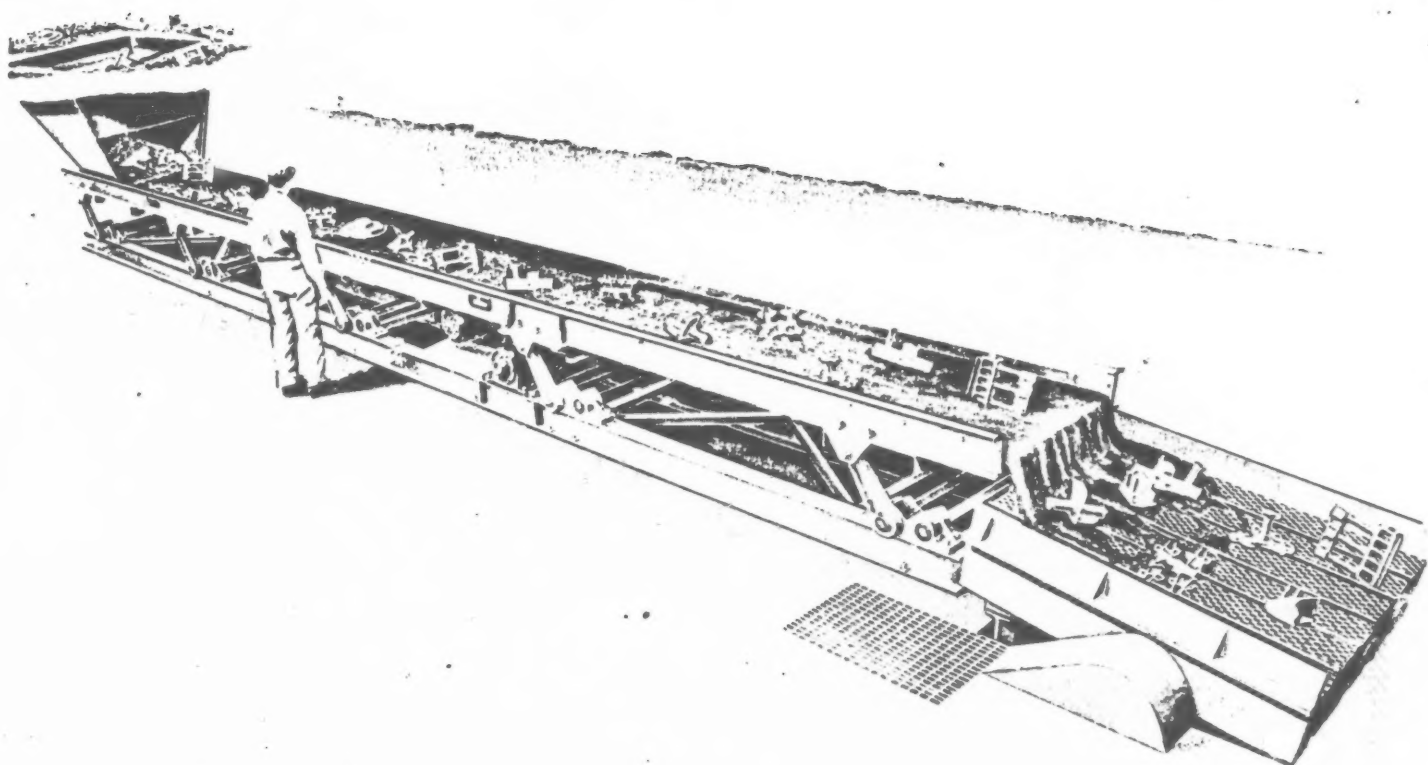
Source: "Comparing Processes for Making
Ductile Iron," E. Modl, FOUNDRY,
July, 1970, pp. 44-46.

ILLUSTRATION OF POURING STATION WITH HORIZONTAL DRAFT,
CANTILEVERED HOOD



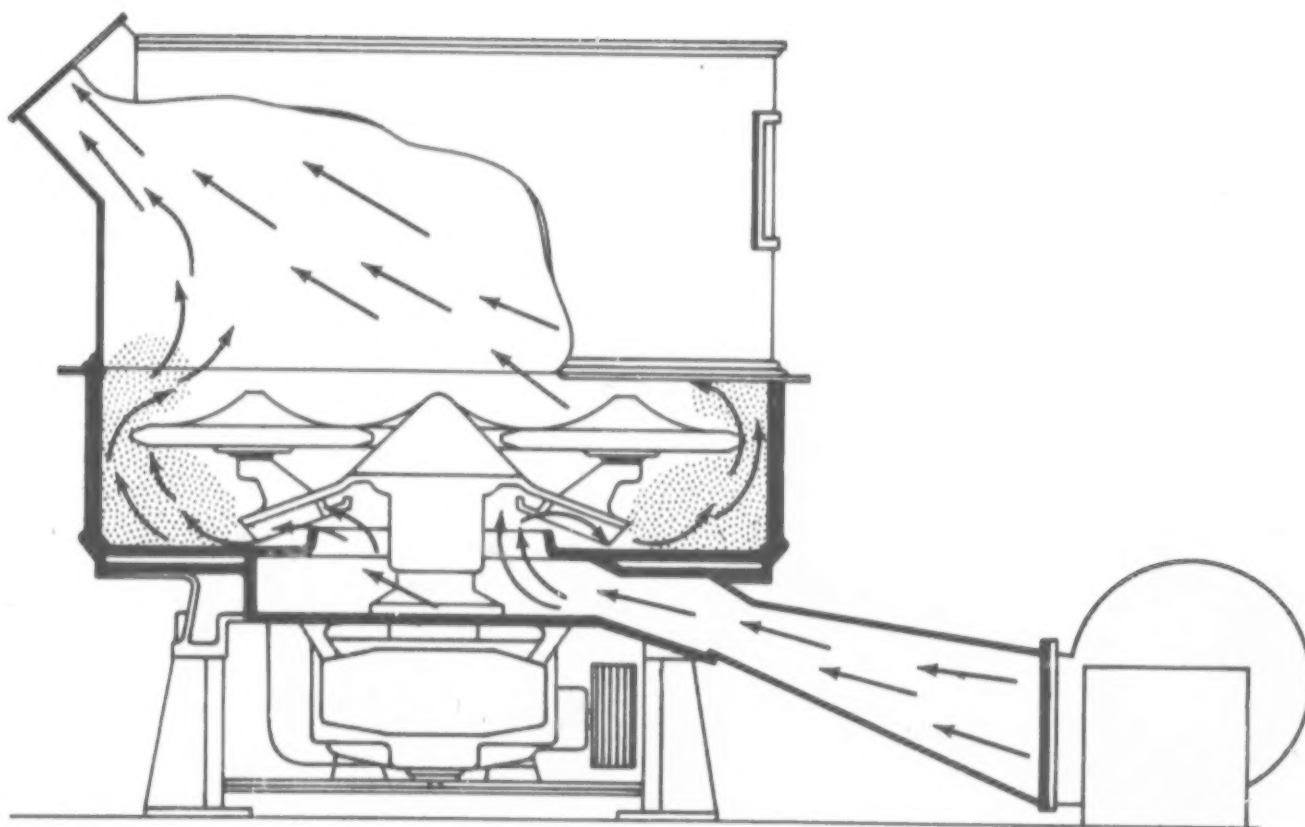
Source: Modern Casting, published by the American
Foundrymen's Society, Inc., November, 1970,
p. 83.

ILLUSTRATION OF SHAKEOUT STATION



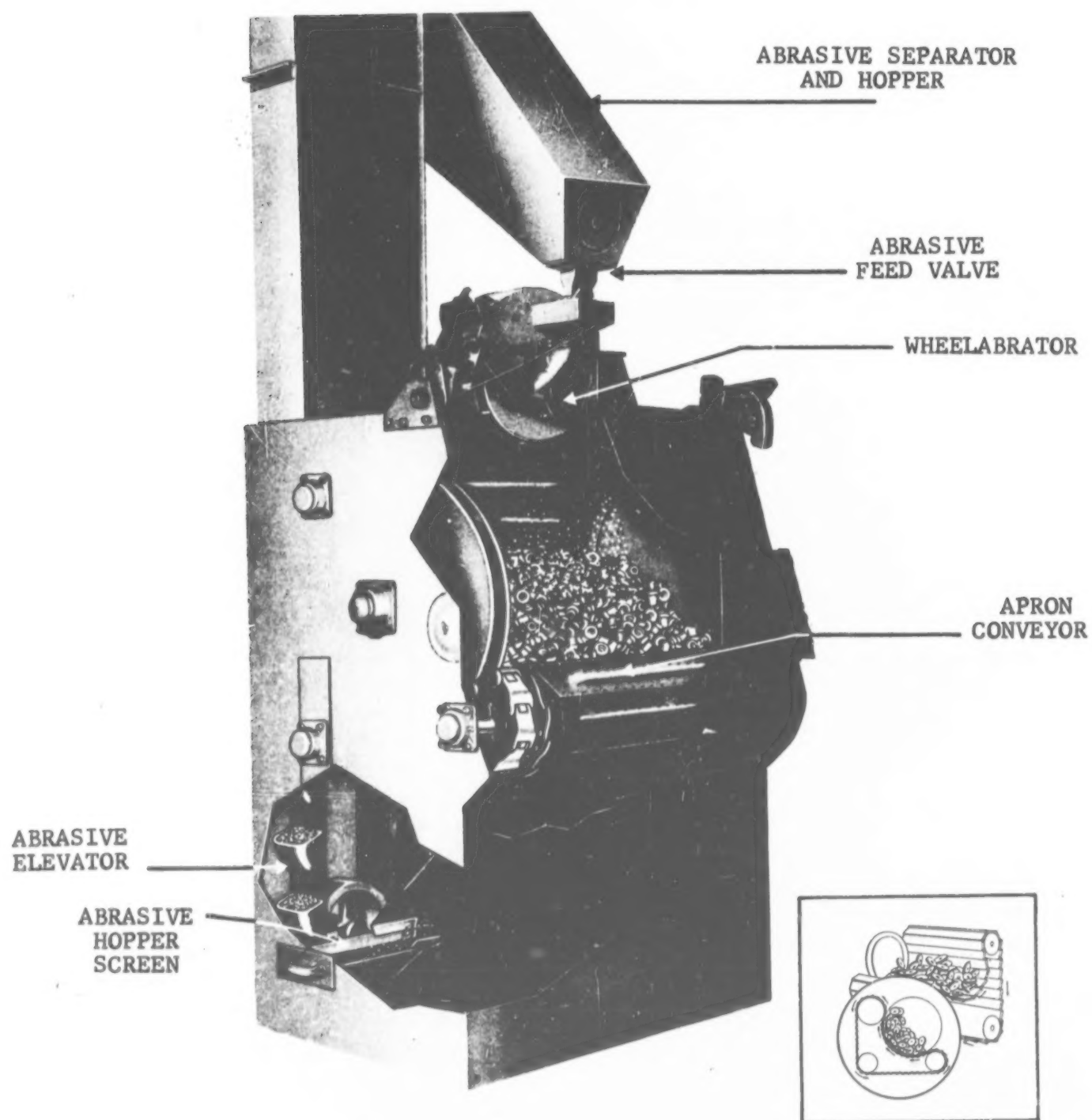
Source: Molding Methods and Materials;
Published by the American
Foundrymen's Society, 1962, p. 205.

ILLUSTRATION OF SAND MULLER



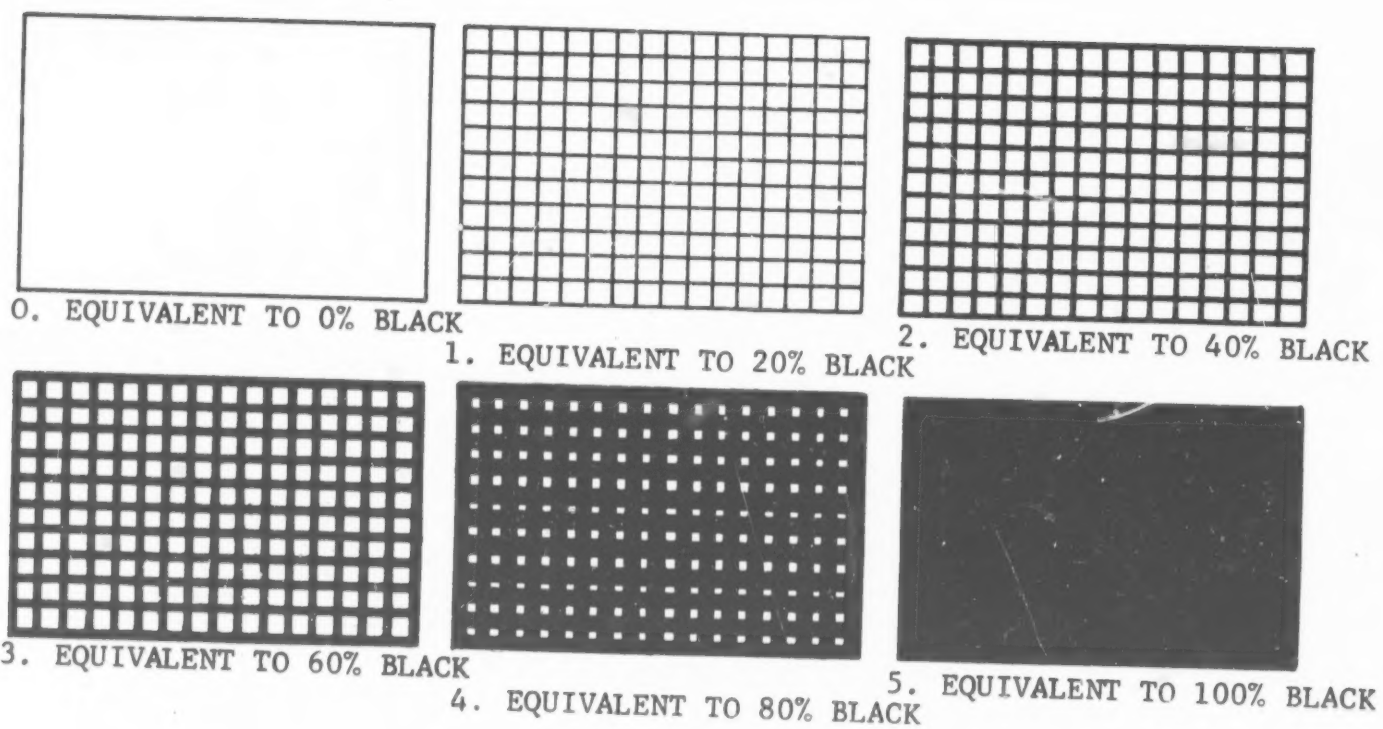
Source: Beardsley & Piper.

ILLUSTRATION OF BLAST CLEANING UNIT



Source: Eclipse Fuel Engineering Company.

RINGELMANN SCALE FOR GRADING
DENSITY OF SMOKE



Source: Control of Emissions from Metal Melting Operations, American Foundrymen's Society.

PERTINENT ASME ITEMS WHICH MUST BE
CONFORMED TO BY PARTIES CONDUCTING
A STACK SAMPLING TEST

- (a) The object or objects of the test.
- (b) Time of making the test.
- (c) That the dust separator is in a satisfactory condition for testing at the time selected.
- (d) Whether the test is to be made by Method A, Method B, or Method C.
- (e) The number, type, and location of dust samplers and other instruments to be employed where alternatives are permitted.
- (f) Method of maintaining constancy of test conditions.
- (g) Gas flow rates or boiler loads at which runs are to be made.
- (h) Method of determining gas flow through separator, i.e., by Pitot tube.
- (i) Number and duration of runs.
- (j) Duration of operation at each test load before sampling is commenced.
- (k) Selection of laboratory for making equipment calibrations, weighing, size analysis and combustible content determinations of the dust samples if equipment and trained personnel for this work are not available at the plant.
- (l) Tolerances or margins, if any, to be applied.

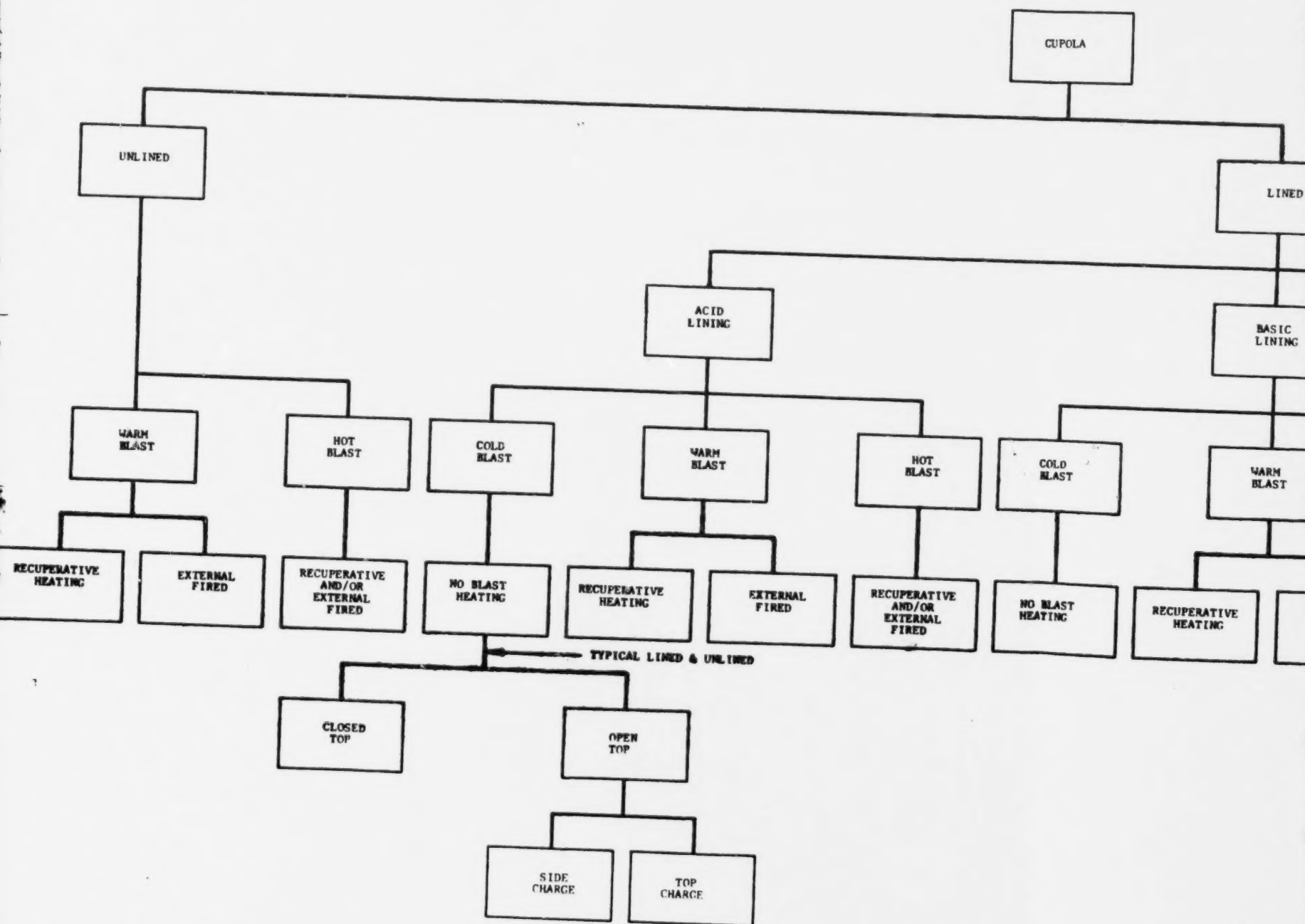
TEST METHODS

Method A. This method is based on the determination of the average dust concentration at the inlet of the separator and at the outlet of the separator. From these data the efficiency can be computed in accordance with the equations given in Section 5 of reference, which are based on the assumption that no change in the mass of gas flowing takes place between the two sampling locations. It is not necessary to know the gas flow rate or total quantity passing through the separator for the duration of each run, nor is it necessary to weigh or sample the dust caught by the separator.

Method B. This method is based on the quantity of dust caught, the dust concentration at the outlet of the separator, and the total quantity of gas passing through the separator. Obviously, this method can be applied only to those installations where the dust can be removed from the hopper in the dry state for the period of each test run. Also, it is necessary to measure the total quantity of gas passing through the separator with reasonable accuracy in order to correlate the average outlet dust concentration with the total quantity of dust caught. For method of computation see Section 5 of reference.

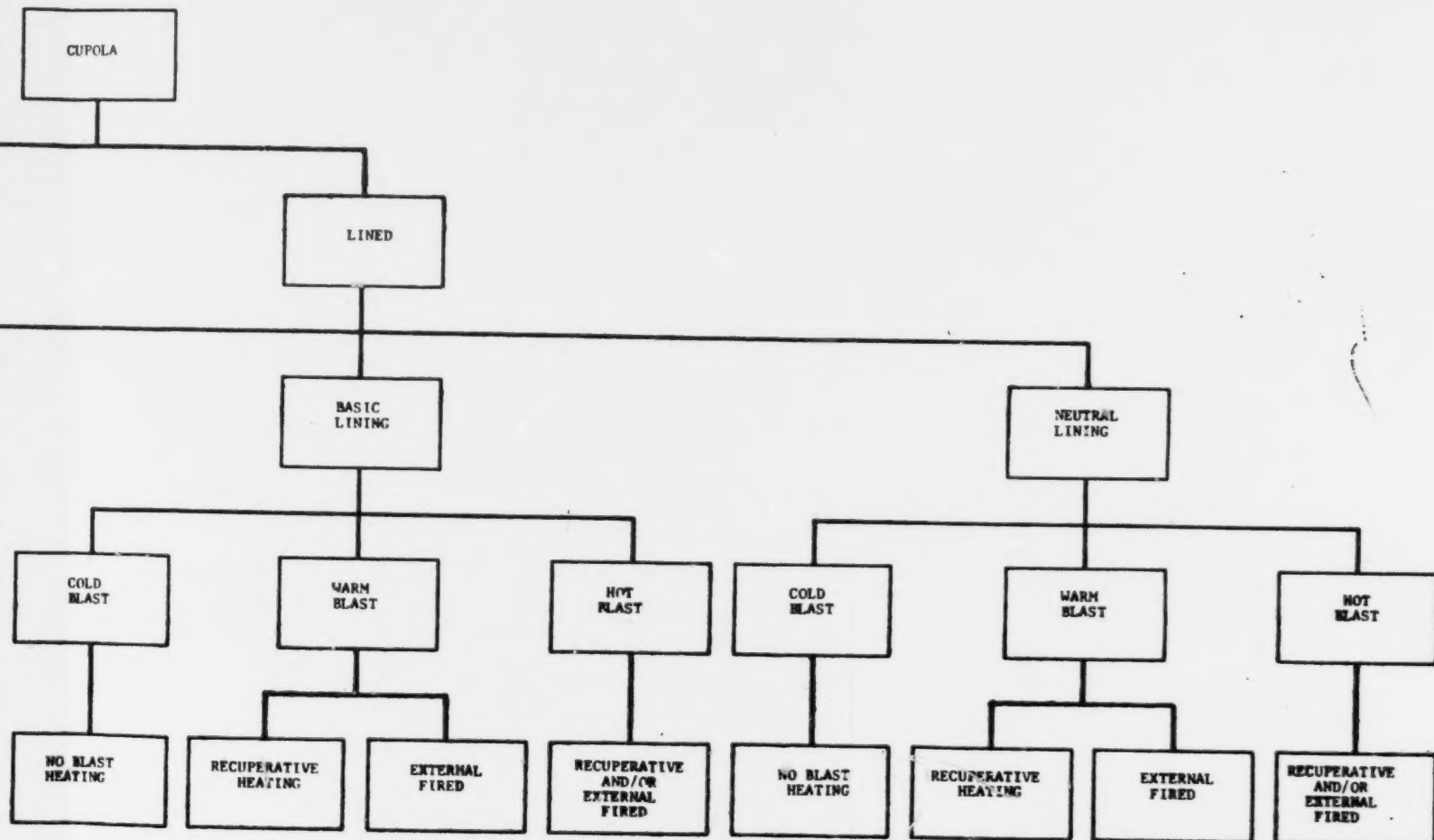
Method C. This method is based on the quantity of dust caught, the dust concentration at the inlet of the separator, and the total quantity of gas passing through the separator. The other factors relative to measurement by this method apply as in Method B. 4

DESIGN FEATURES OF THE CUPOLA
LINING, BLAST & BLAST HEATING



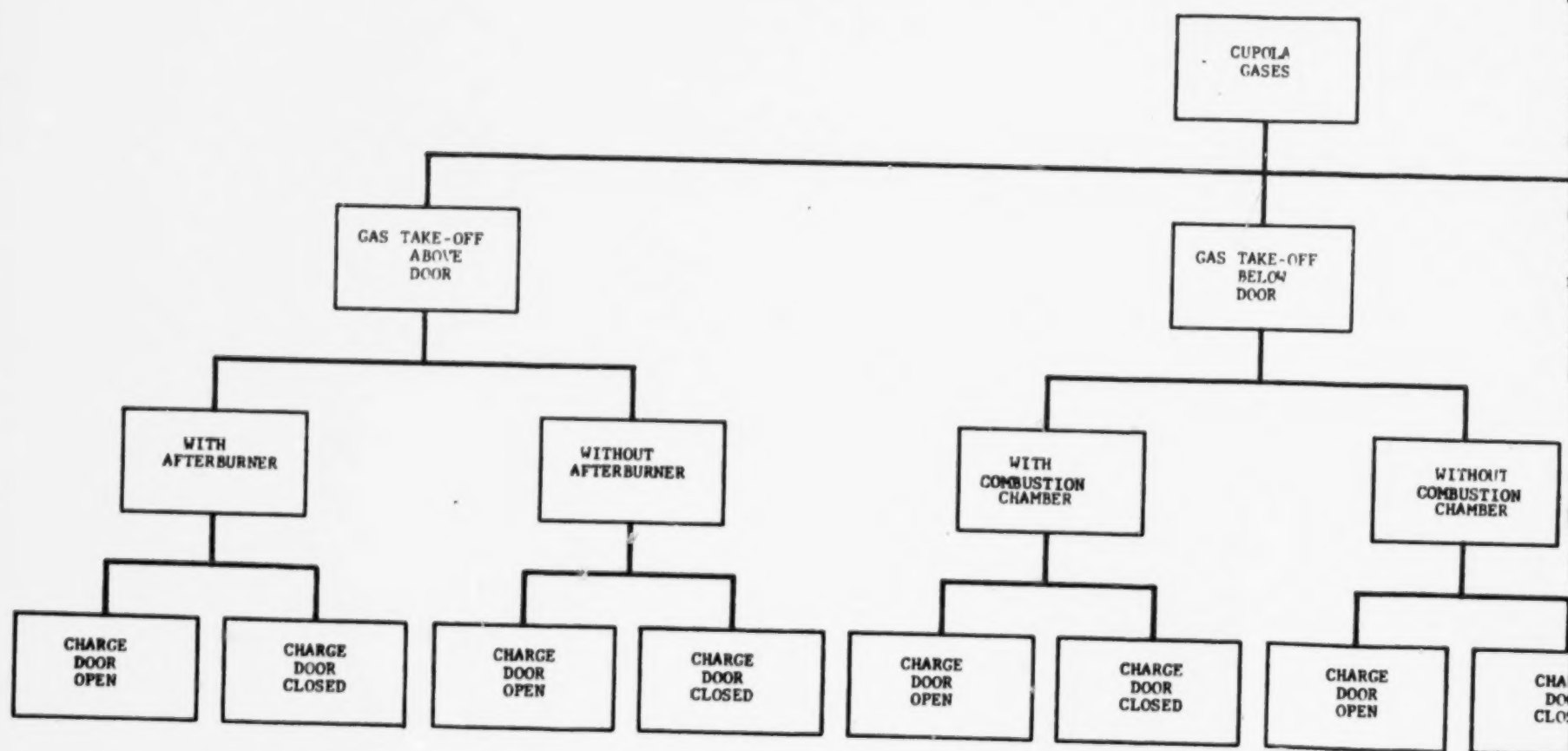
A

DESIGN FEATURES OF THE CUPOLA
LINING, BLAST & BLAST HEATING



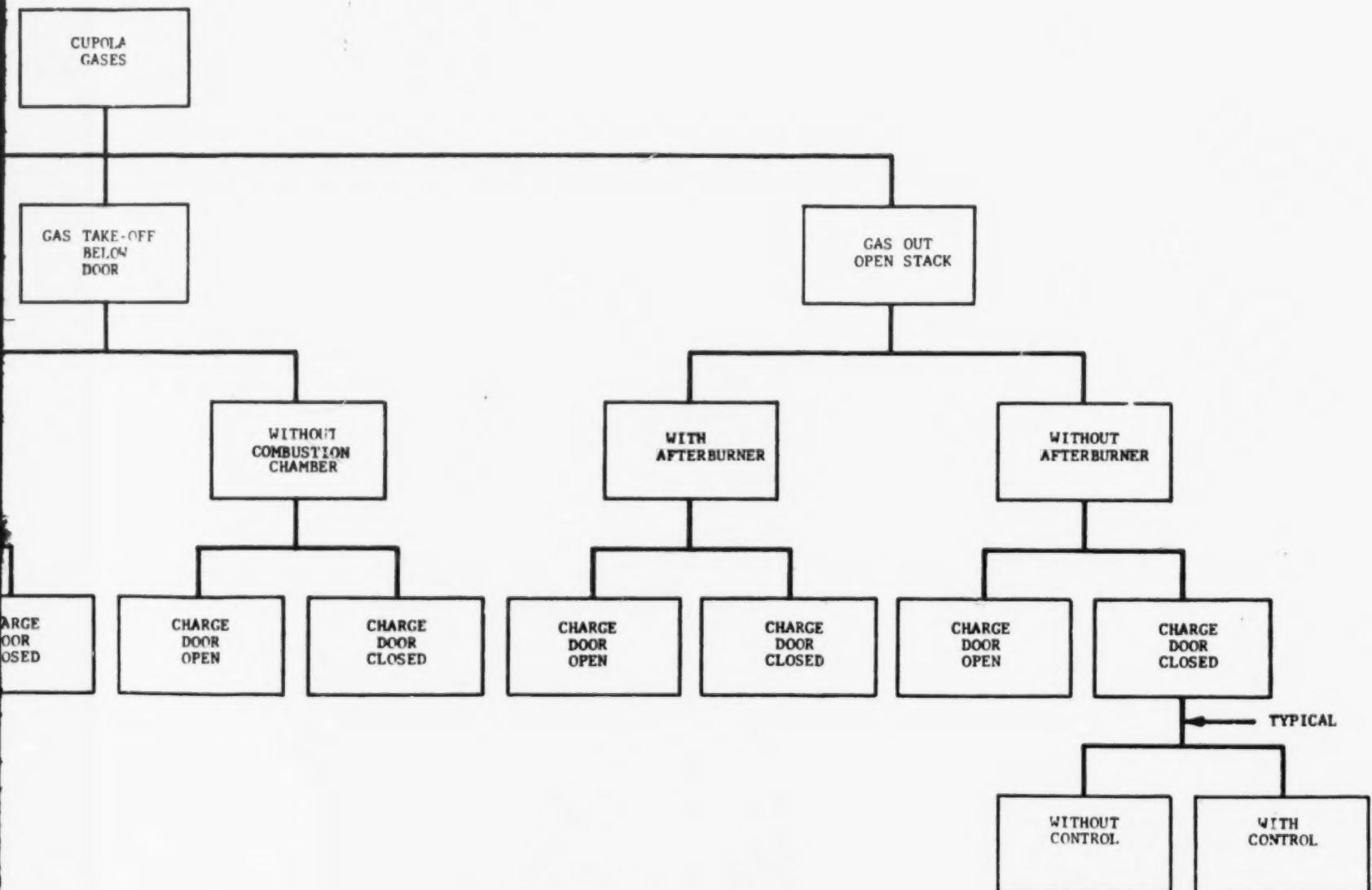
B

DESIGN FEATURES OF THE CUPOLA
GAS TAKE-OFF, AFTERBURNER, COMBUSTION
CHAMBER, AND CHARGE DOOR



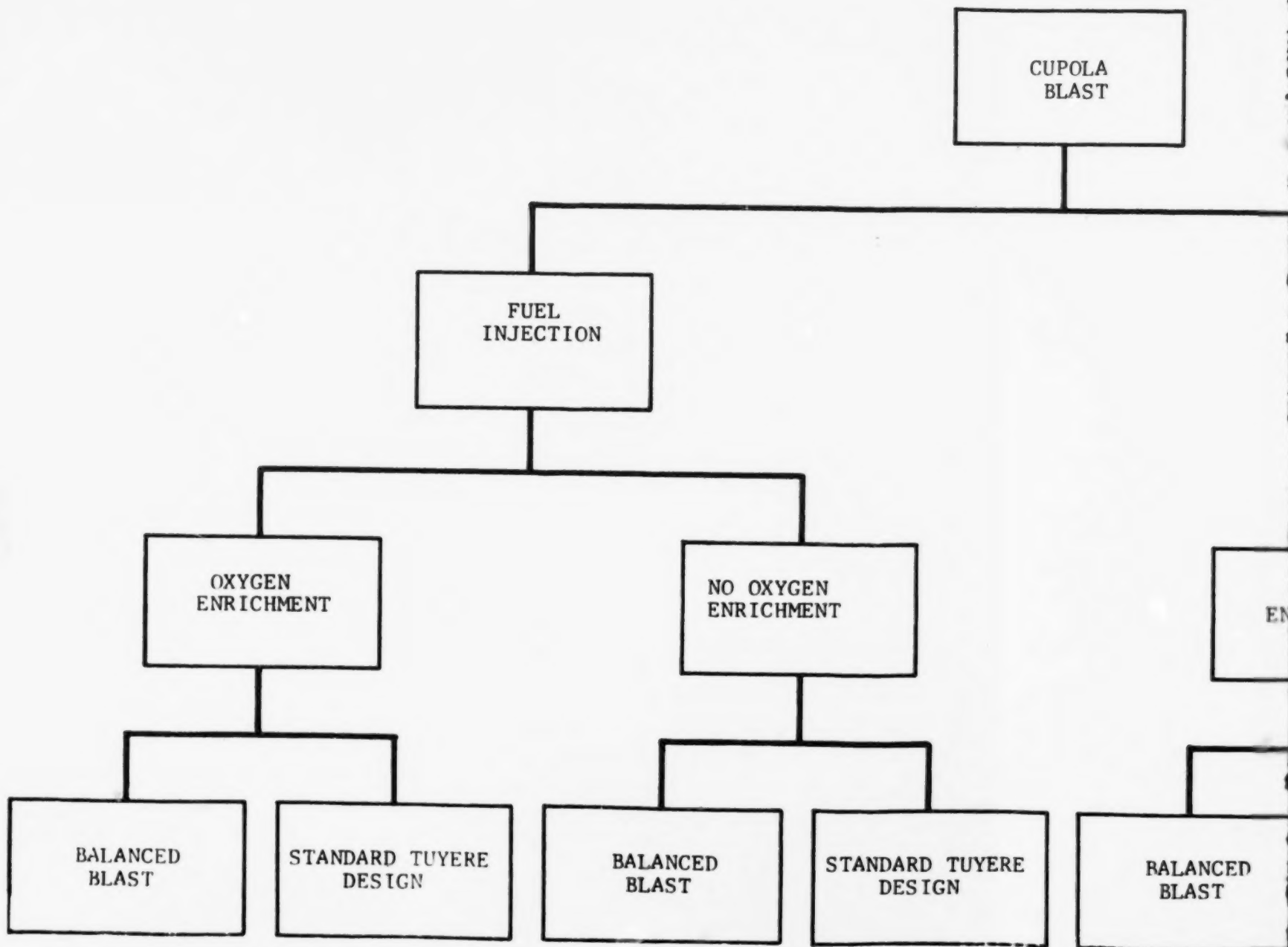
A

DESIGN FEATURES OF THE CUPOLA
GAS TAKE-OFF, AFTERBURNER, COMBUSTION
CHAMBER, AND CHARGE DOOR



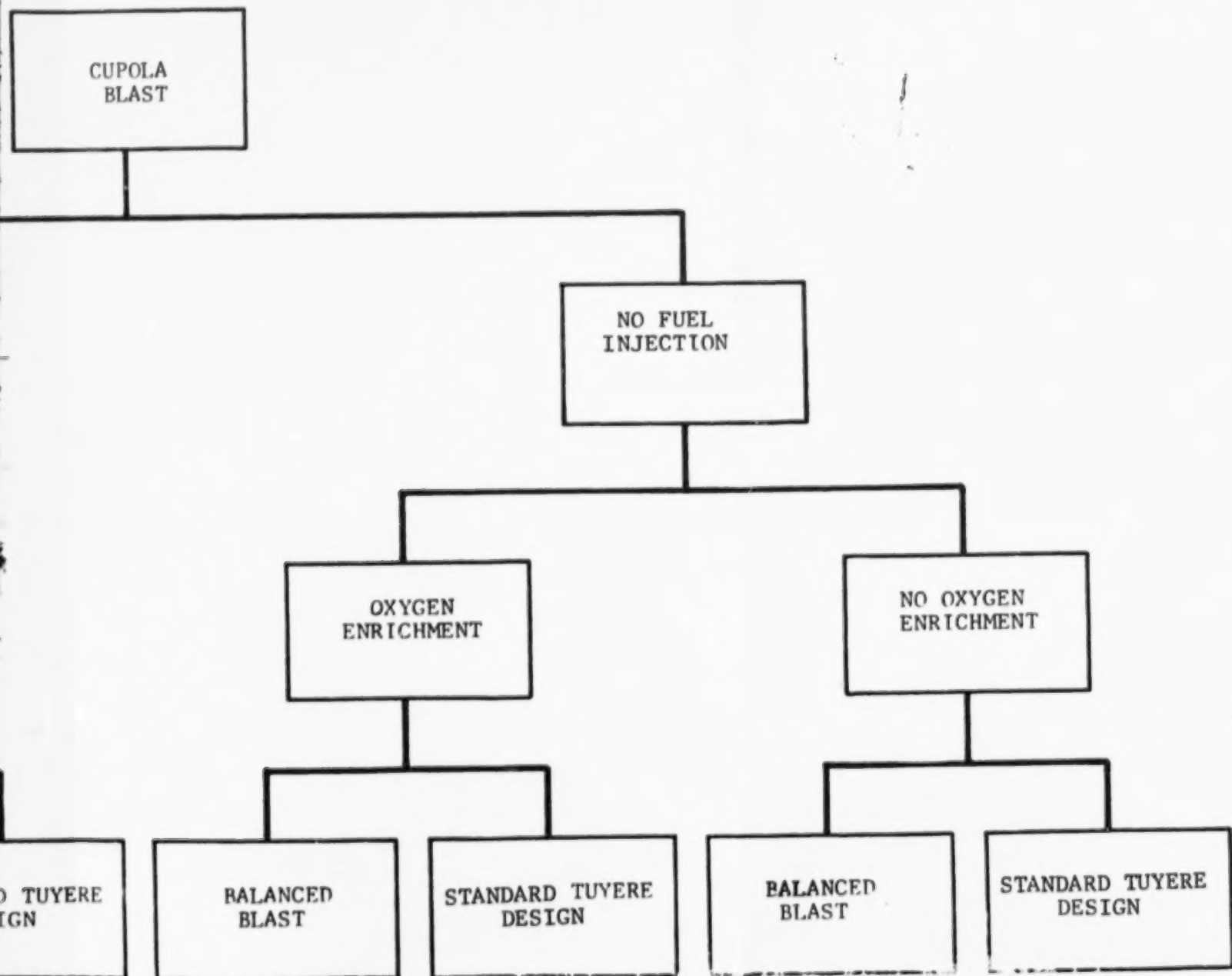
B

DESIGN FEATURE OF THE CUPOLA
FUEL INJECTION, OXYGEN ENRICHMENT
AND TUYERE DESIGN



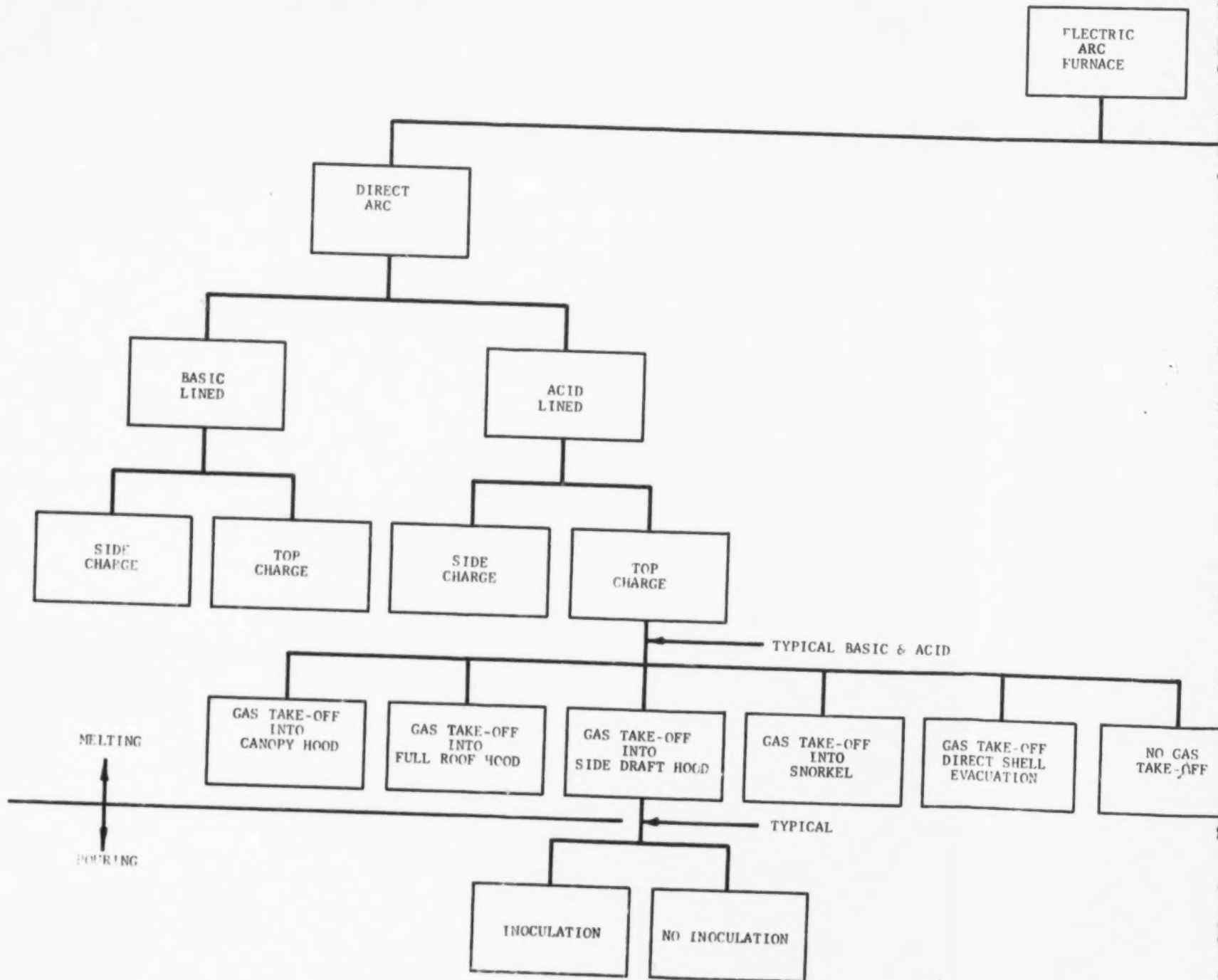
A

MAIN FEATURE OF THE CUPOLA
INJECTION, OXYGEN ENRICHMENT
AND TUYERE DESIGN



B

DESIGN FEATURES OF THE ELECTRIC ARC



A

EXHIBIT VI-4

FEATURES OF THE ELECTRIC ARC

ELECTRIC
ARC
FURNACE

INDIRECT
ARC

ACID

GAS TAKE-OFF
DIRECT SHELL
EVACUATION

NO GAS
TAKE-OFF

GAS TAKE-OFF
INTO
CANOPY HOOD

NO GAS
TAKE-OFF

INOCULATION

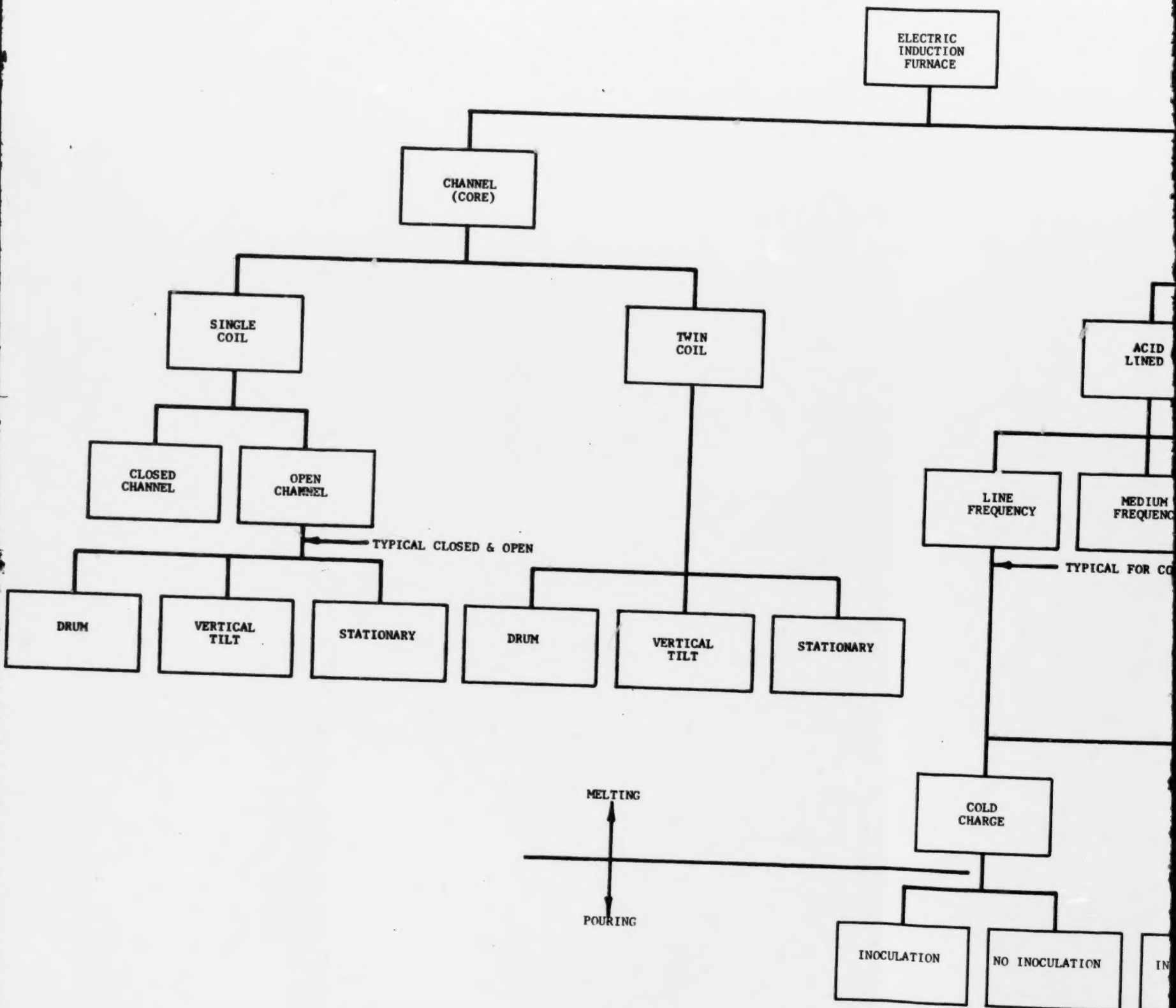
NO INOCULATION

INOCULATION

NO INOCULATION

B

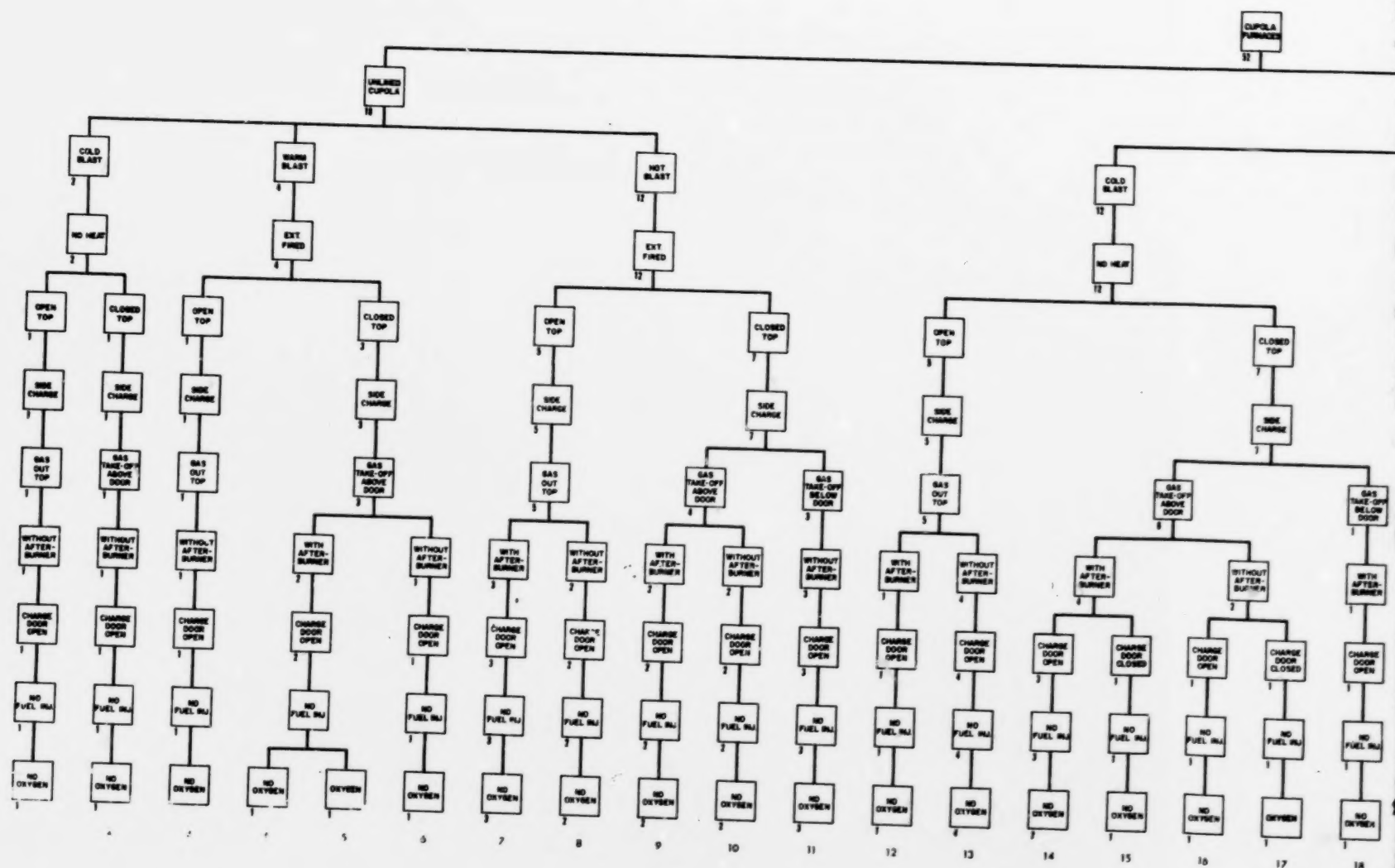
DESIGN FEATURES OF THE INDUCTION FURNACE



A

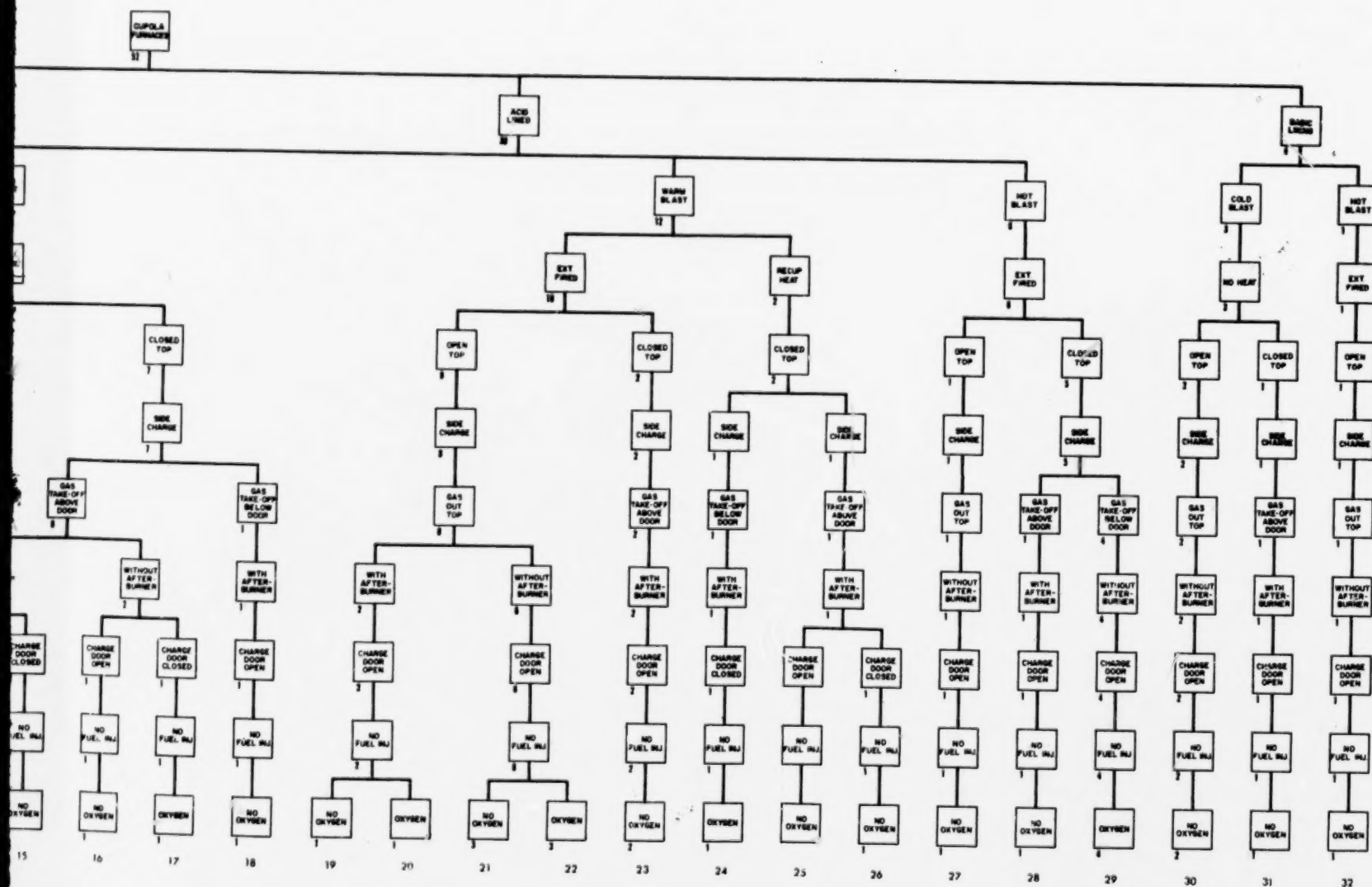


CUPOLA FURNACES FOUND IN



A

A FURNACES FOUND IN PRACTICE



B

CHEMICAL COMPOSITION OF CUPOLA PARTICULATE EMISSIONS

Foundry Number	Percent by Weight in Cupola Effluent						
	Iron Oxide	Magnesium Oxide	Manganese Oxide	Lead Oxide	Aluminum Oxide	Zinc Oxide	Silicon Dioxide
66	11.1%						12.3%
85	14.7	1.3%		1.4%			28.7
90							56.3
113	8.6		3.7%		.05%		31.8
116	10.0	5.0	10.0		5.0	1.0%	10.0
146	33.0		1.0	5.0		38.0	20.0
150	11.6	1.0	5.5	20.0	1.4	14.7	30.1
							42.0%
							0.9
							3.1
							3.0
							1.0
							1.1
							24.0%
							27.0
							5.0

Note: Quantities as reported. They do not add up to 100%.

PARTICLE SIZE DISTRIBUTION-CUPOLA EMISSIONS

Foundry	Cumulative Percent by Weight						
	Diameter in Microns						
	-1	-2	-5	-10	-20	-50	-100 -200
9		30%	50%	65%	82%	90%	99%
14		64	82	98	99		
18			2	12	34	92	99
26		13	28	45	55	60	99%
32			54	86	98	99	99
67			14	15	15	21	99
67					19	25	99
146						99	99
151		0.6	2	3	8	99	99
A1			4	5.5	7	13.7	75
B1			11	13	32	53	75
C1			8	12	17	28	69
12			18	25	38	62	89
22			17	26	36	53	
32			24	28	23	42	
42			26	30	32	44	
A2	0	7	25	32	34	41	56
B2	0	7	24	41	47	32	69
							61
							81

- Sources:
1. The Cupola and Its Operation,
Third Edition, 1965,
American Foundrymen's Society,
p. 82.
 2. Air Pollution Engineering Manual,
Public Health Service Publication,
No. 999-AP-40, 1967
Department of Health, Education, and Welfare.

**PARAMETERS OF CUPOLA FURNACES - LINEAR REGRESSION ANALYSES
OF EMISSIONS AFFECTED BY FURNACE DESIGN FACTORS**

Foundry Number	Furnace Classifi- cation	Cupola Furnace Parameters										Oxygen Enrich- ment	Emissions Lb./Ton Melt
		Lining Type	Blast Design	Blast Heating	Top Open or Closed	Charging Top or Side	Gas Takeoff	After- burner	Charging Door Open or Closed	Fuel Injection			
151	10	4	1	3	1	2	1	0	1	0	0	7.5	
12	27	1	1	3	2	2	8	0	1	0	0	9.6	
5	14	1	3	1	1	2	1	2	1	0	0	11.4	
146	17	1	3	1	1	2	1	0	2	0	1	12.1	
12	32	2	1	3	2	2	8	0	1	0	0	12.4	
50	16	1	3	1	1	2	1	-1	1	0	0	15.1	
37	14	1	3	1	1	2	1	2	1	0	0	17.4	
26	14	1	3	1	1	2	1	2	1	0	0	18.3	
152	16	1	3	1	1	2	1	-1	1	0	0	19.5	
7	18	1	3	1	1	2	2	2	1	0	0	19.9	
45	10	4	1	3	1	2	1	0	1	0	0	20.4	
-69	29	1	1	3	1	2	2	0	1	0	1	20.6	
134	6	4	1	3	1	2	1	-1	1	0	0	20.8	
150	24	1	2	2	1	1	2	1	2	0	1	22.9	
9	23	1	2	3	1	2	1	2	1	0	0	36.0	
9	14	1	3	1	1	2	1	2	1	0	0	37.6	
35	4	4	2	3	1	2	1	2	1	0	0	40.4	
125	9	4	1	3	1	2	1	2	1	0	0	40.4	
160	2	4	3	1	1	2	1	0	1	0	0	40.5	
-71	11	4	1	3	1	2	2	0	1	0	0	44.7	
84	9	4	1	3	1	2	1	2	1	0	0	45.7	
29	4	4	2	3	1	2	1	6	1	0	0	46.6	
18	30	2	3	1	2	2	8	-1	1	0	0	48.5	
67	9	4	1	3	1	2	1	1	1	0	0	50.0	
69	13	1	3	1	2	2	8	0	1	0	0	53.4	
67	9	4	1	3	1	2	1	1	1	0	0	66.3	

Note: See Appendix B, Exhibit 2 for description of cupola furnace parameter codes.

MULTIPLE LINEAR REGRESSION CORRELATION MATRICESCORRELATION MATRIX FOR ACID LINED CUPOLAS

<u>Particulate Emissions Lb./Ton</u>	<u>Specific Melt Rate T/Hr./S.F.</u>	<u>Specific Blast Rate SCFM/S.F.</u>	<u>Metal to Coke Ratio</u>	<u>Blast Temperature °F</u>
1.000	-0.330	0.653	0.223	0.294
-0.330	1.000	-0.561	-0.215	-0.473
0.653	-0.561	1.000	0.026	0.268
0.223	-0.215	0.026	1.000	0.874
0.294	-0.473	0.268	0.874	1.000

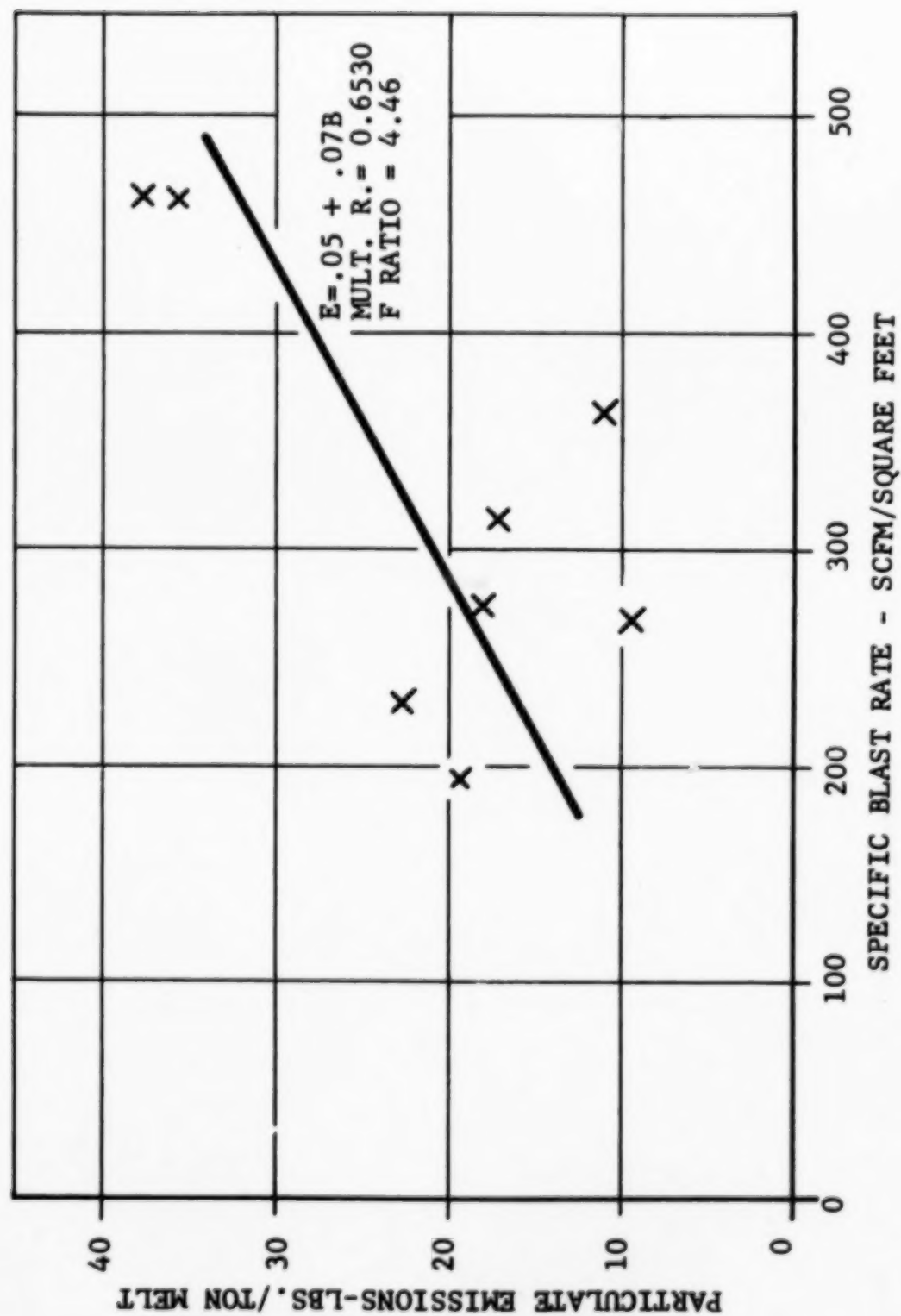
CORRELATION MATRIX FOR UNLINED CUPOLAS

<u>Particulate Emissions Lb./Ton</u>	<u>Specific Melt Rate T/Hr./S.F.</u>	<u>Specific Blast Rate SCFM/S.F.</u>	<u>Metal to Coke Ratio</u>	<u>Blast Temperature °F</u>
1.000	0.226	0.600	-0.703	-0.008
0.226	1.000	0.448	0.022	0.130
0.600	0.448	1.000	-0.454	0.131
-0.703	0.022	-0.450	1.000	0.060
-0.008	0.130	0.131	0.060	1.000

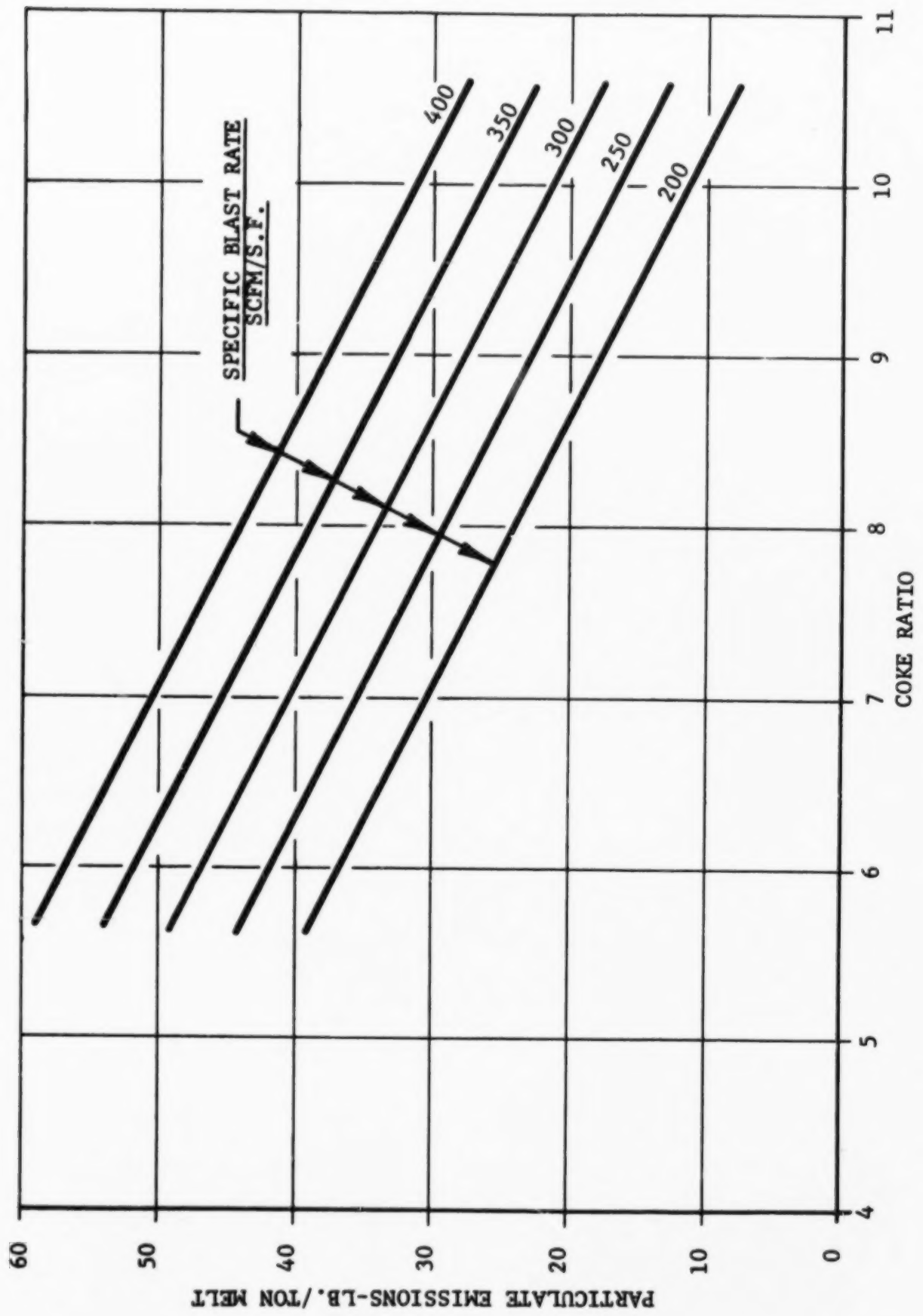
LINEAR REGRESSION ANALYSIS OBSERVATIONS

<u>Foundry Number</u>	<u>Cupola Classifi- cation</u>	<u>Particulate Emissions Lb./Ton</u>	<u>Specific Melt Rate T/Hr./S.F.</u>	<u>Specific Blast Rate SCFM/S.F.</u>	<u>Metal to Coke Ratio</u>	<u>Temperature OF</u>
<u>Acid Lined Cupolas</u>						
12	27	9.5	0.56	269	11.5	1,100
5	14	11.4	.73	364	8	70
37	14	17.4	.64	317	6	70
26	14	18.3	.63	274	8	70
7	18	19.9	.71	194	9	700
150	24	22.9	.78	231	10.5	750
9	23	36.0	.57	462	10	750
9	14	37.0	.57	462	10	
<u>Basic Lined Cupola</u>						
18	30	48.5	0.48	357	6	70
<u>Unlined Cupolas</u>						
151	10	7.5	0.50	248	9	1,000
45	10	20.4	.52	238	9	1,400
35	4	40.4	.76	324	8	600
125	9	40.4	.55	244	10	1,000
160	2	40.5	.36	317	8	1,000
84	9	45.7	.60	238	7	1,000
29	4	46.6	.31	252	6	750
67	9	66.3	.63	352	6	1,200
67	9	50.0	.70	352	7	1,400

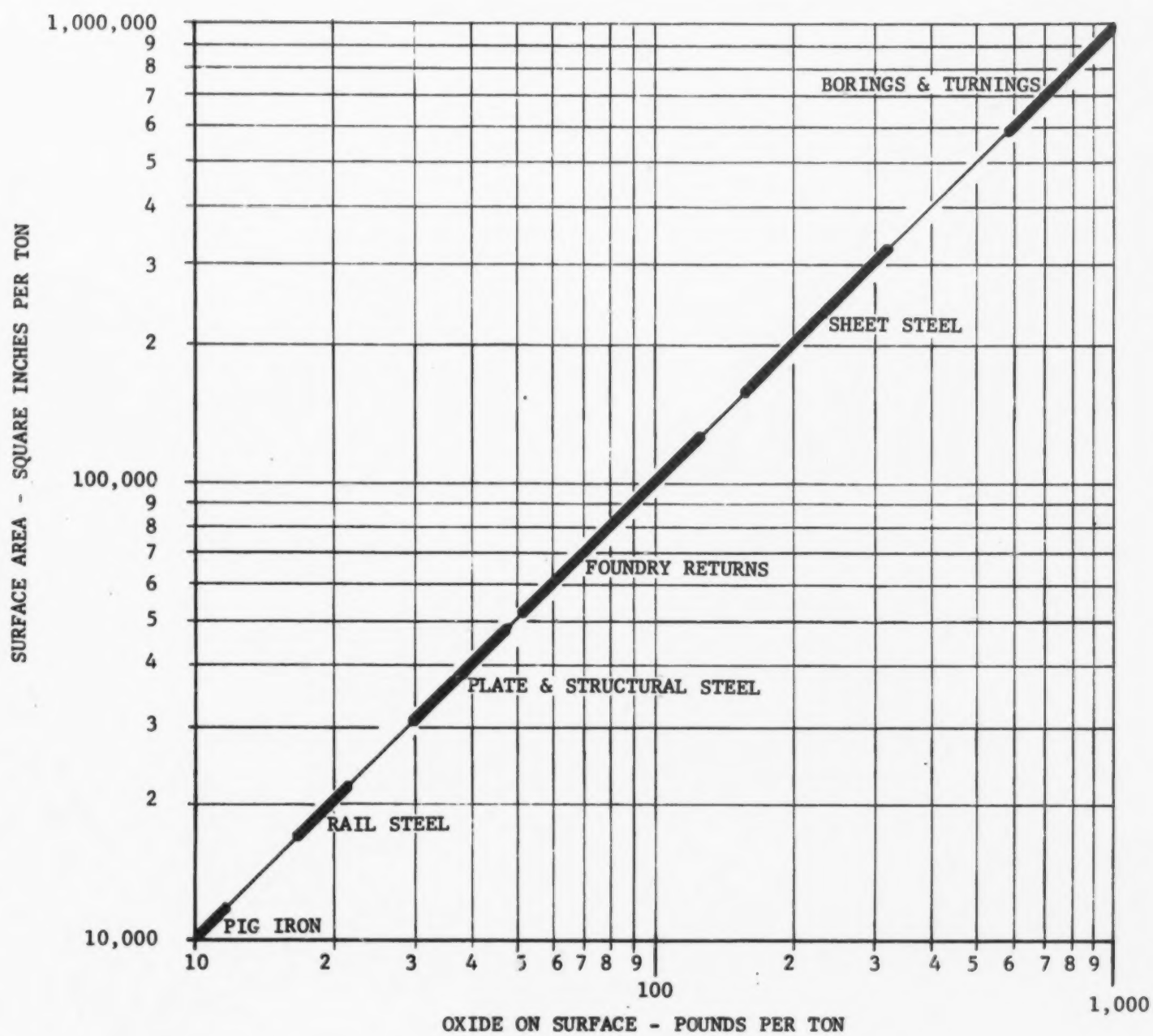
PARTICULATE EMISSIONS
VS. SPECIFIC BLAST RATE
FOR ACID LINED CUPOLAS



EFFECT OF SPECIFIC BLAST RATE AND COKE
RATE ON PARTICULATE EMISSIONS FROM UNLINED CUPOLAS



EFFECT OF TYPE OF SCRAP
ON AMOUNT OF IRON OXIDE PRESENT



SIZE DISTRIBUTION FOR THREE ELECTRIC
ARC INSTALLATIONS

<u>Particle Size Distribution, Microns</u>	<u>Foundry A*</u>	<u>Foundry B</u>	<u>Foundry C</u>
Less than 1	5%	8%	18%
Less than 2	15	54	61
Less than 5	28	80	84
Less than 10	41	89	91
Less than 15	55	93	94
Less than 20	68	96	96
Less than 50	98	99	99

Note: *Foundry A provided an agglomerated sample and is, therefore, less representative.

CHEMICAL ANALYSIS OF ELECTRIC ARC EMISSIONS

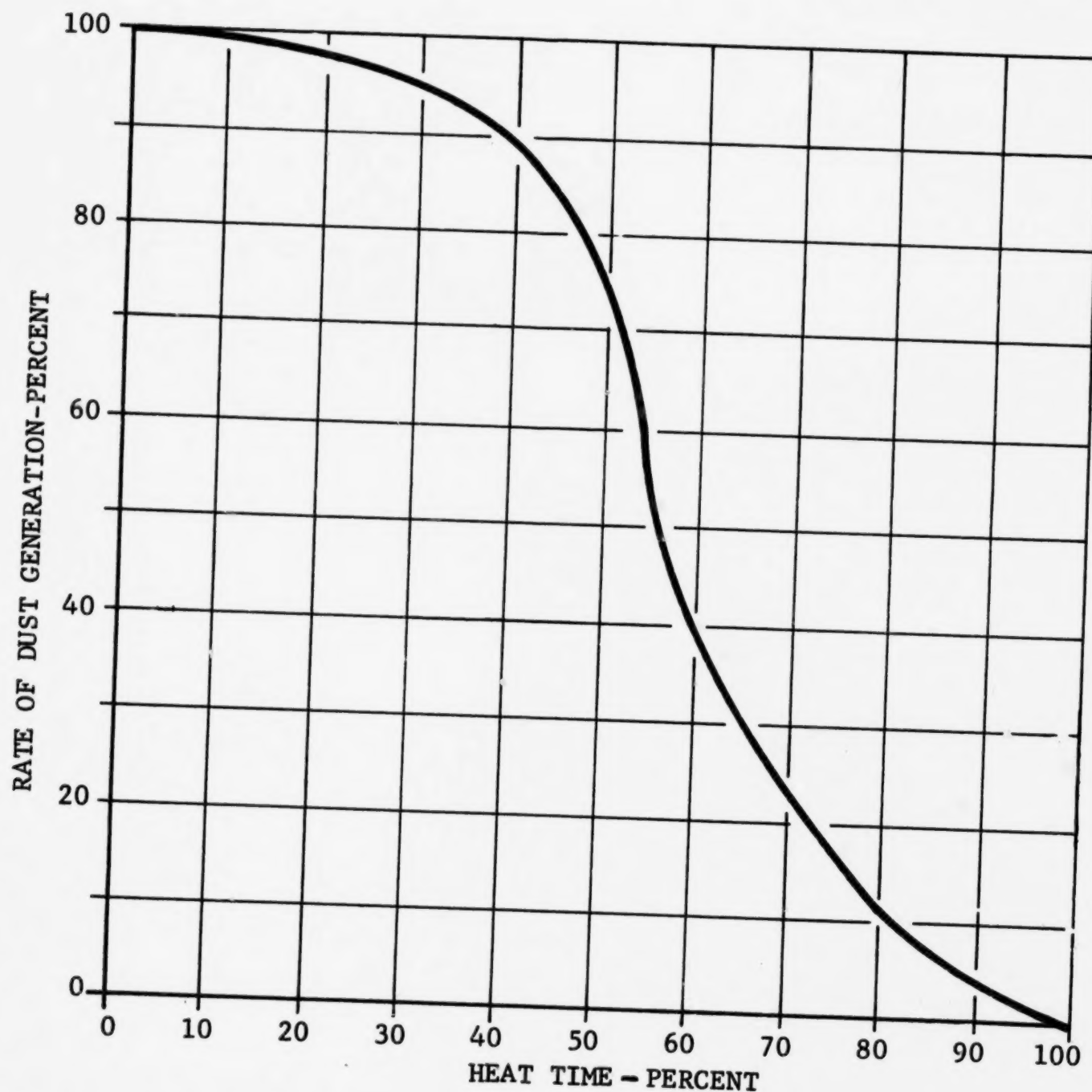
<u>Oxides</u>	<u>Foundry A</u>	<u>Foundry B</u>	<u>Foundry C</u>
Iron	75%-85%	75%-85%	75%-85%
Silicon	10	10	10
Magnesium	2	0.8	1
Manganese	2	2	2
Lead	1	2	0.5
Aluminum	0.5	1	0.5
Calcium	0.3	0.2	0.8
Zinc	0.2	2.	0.3
Copper	0.04	0.03	0.01
Lithium	0.03	0.03	0.03
Tin	0.03	0.3	0.02
Nickel	0.02	0.03	0.01
Chromium	0.02	0.07	0.02
Barium	0.02	0.07	0.01
Loss on Ignition	8.87	3.1	0
Ash	91.93	96.9	100

**EMISSIONS DATA FROM
ELECTRIC ARC MELTING FURNACES**

Number	Furnace Shell Diameter Feet	Furnace Charge Tons	Furnace Cycle Hours	Emissions Produced Lb/Ton Charge	Emissions Control System	
					Per Furnace Capacity-CFM	Gas Temp- °F
1	11.0	15	1.15	12.0(Est.)	50,000	250
2	12.0	20	1.5	6.0	65,000	120
3	8.0	5	1.0	20.0	17,000	120
4	12.0	20	2.5	18.3	32,000	250
5	7.0	3	1.75	10.0	26,000	225
6	12.0	25	4.0	4.0	63,000	200
7	8.0	5	1.0	40.0	20,000	150
8	7.0	3	1.75	12.7	10,000	220
9	7.0	2	2.0	10.7	19,000	
10	7.0	2	1.3	13.4		
11	7.0	3	2.0	5.3		
12	9.0	6	2.3	15.3		
13	9.0	6	2.0	12.8		
14	11.0	18	3.0	6.1		
15	9.0	6	1.2	29.4		
16	9.0	6	1.75	12.7		
17	8.0	4	2.0	11.0	13,000	130
18	11.0	14	1.75	7.5	19,000	190
19	12.0	19	1.7	15.0	42,000	170

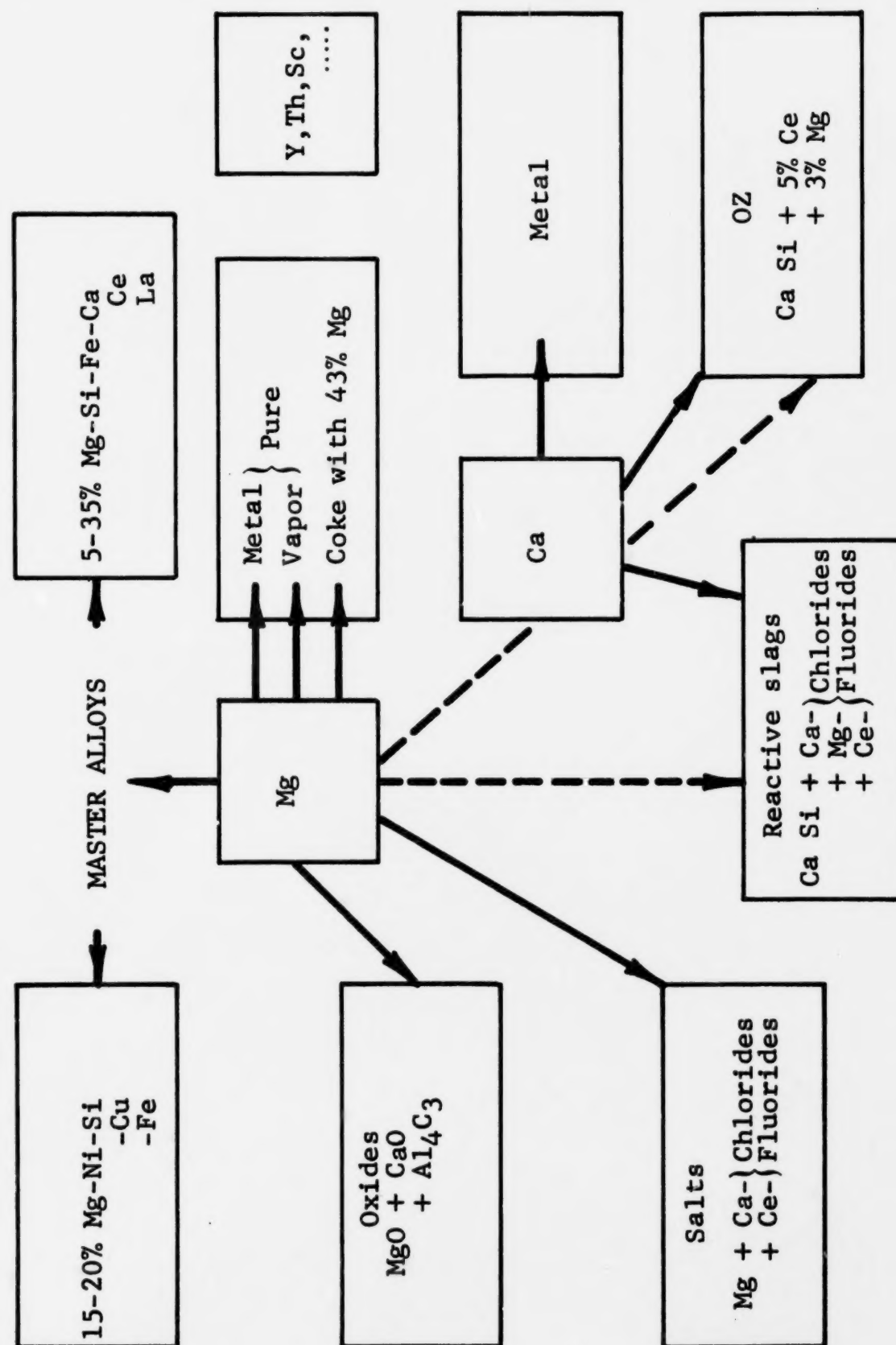
Sources: 1- 4 Foundry Visits
5- 9 AFS Foundry Air Pollution Manual
10-19 Los Angeles Air Pollution Manual

RELATIONSHIP BETWEEN RATE OF EMISSIONS
AND HEAT CYCLE FOR ELECTRIC ARC MELTING



Source: Coulter, 1954, Los Angeles Air Pollution Manual.

TREATMENT AGENTS FOR PRODUCING DUCTILE IRON



Source: Modl, Comparing Processes for Making Ductile Iron, Foundry, July, 1970.

MAGNESIUM TREATMENT SYSTEMS EMISSIONS REPORT FOR
DUCTILE IRON PRODUCTION AND GRAY IRON DESULFURIZATION

Iron Treated - 30 Tons per Hour
Inoculant Added - 20-22 Pounds per Ton Iron
Inoculants Used - { Soda Ash
 MgFeSi-(10% Mg)
 75% Fe
Emissions Produced - 100 Pounds per Hour
 3.3 Pounds per Ton Iron
Emissions Analysis - 32% MgO
 18.7% Fe₂O₃
 9.5% CO₂
 4.2% SiO₂
 2.5% S
 1.1% C
 0.6% CaO
 Balance Na₂O

Source: Foundry Visitations, Foundry Number 0150.

Molding Sand Gas Analyses

	A 4% Bentonite Oven Dried	B 4% Bentonite 2.5% H ₂ O	C 4% Bentonite 5% Water	D 4% Bentonite 1% Cereal Dried	E 4% Bentonite 3.4% H ₂ O	F 1.5% Cereal Core Oil 1.0% Kerosene 1.0% Dried
--	------------------------------------	---	----------------------------------	---	---	---

CO ₂	4.9	3.3	2.0	6.5	2.8	5.0
O ₂	9.2	6.2	2.9	7.4	1.7	5.2
CO	2.4	6.3	11.3	10.8	11.5	30.4
H ₂	0.9	33.0	46.1	2.5	50.3	25.6
Paraffins	0	1.2	0	0.4	2.9	2.2
N ₂	82.6	49.7	37.7	72.4	30.8	31.6
Percent O ₂ of O ₂ +N ₂	15.7	20.2	21.7	21.0	25.0	44.5
CO/CO ₂	0.49	1.91	5.7	1.66	4.10	6.08
Percent C	7.3	9.6	13.3	17.3	14.3	35.4

	G 4% Cereal 4% Bentonite 4% Water	H 4% Cereal 4% Bentonite Dry	I Oil Drag	J Oil Check	K Oil Cope	L Steel Cavity & Sprue
--	--	---------------------------------------	------------------	-------------------	------------------	---------------------------------

CO ₂	2.5	2.3	6.4	6.4	6.8	5.0
O ₂	3.0	6.2	4.3	5.5	8.9	9.4
CO	30.5	28.7	7.9	11.1	2.5	4.1
H ₂	46.0	24.8	2.6	7.5	0.6	0.5
Paraffins	4.6	0.6	0.1	0	0	0.2
N ₂	13.2	37.4	78.7	69.5	81.2	80.8
Percent O ₂ of O ₂ +N ₂	63.0	39.0	15.7	17.4	17.2	16.9
CO/CO ₂	12.2	12.5	1.23	1.73	.37	0.82
Percent C	33.0	31.0	14.3	17.5	9.3	9.1

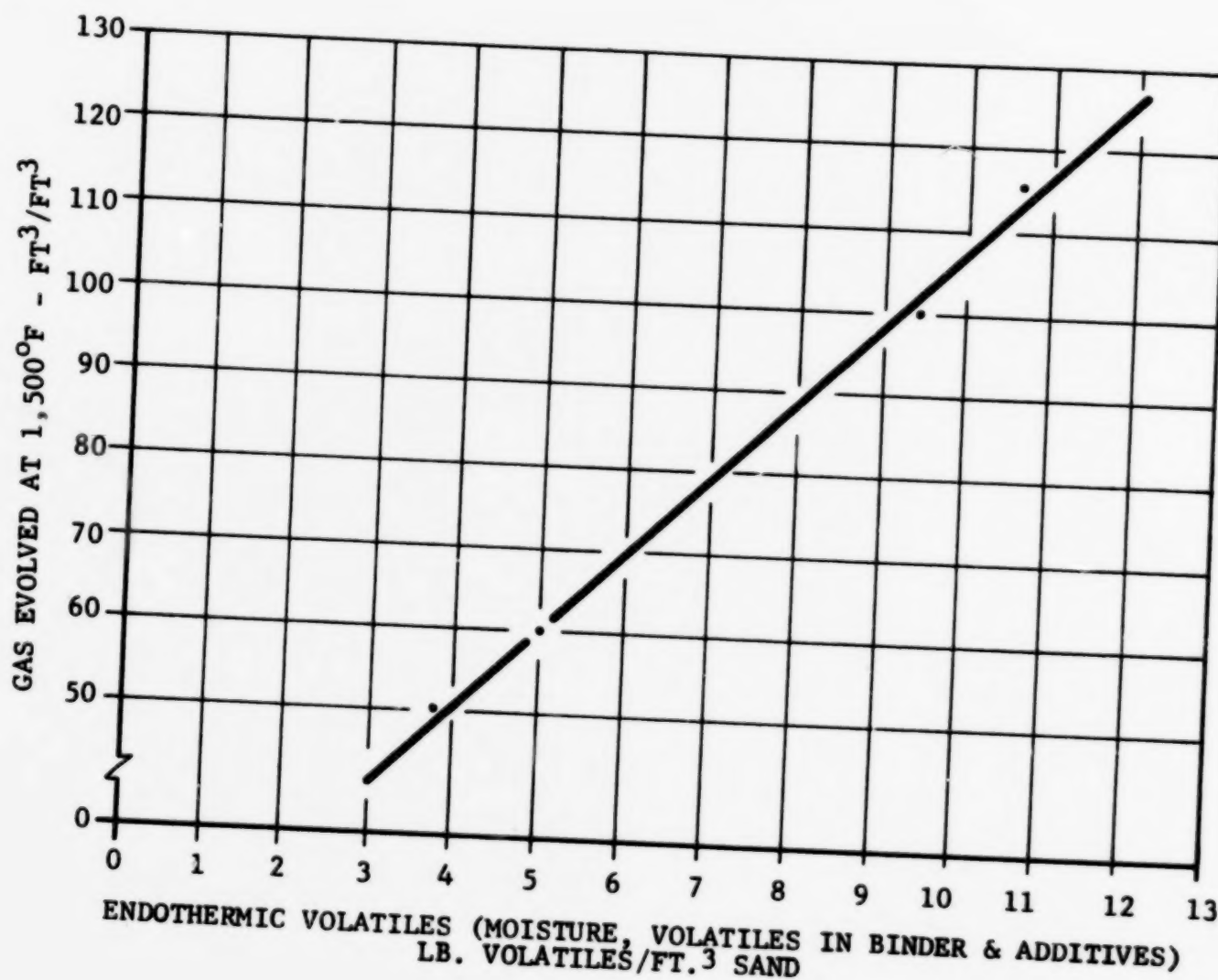
Source: "Nature of Mold Cavity Gases," Locke & Ashbrook, AFS Transactions, 1950.

MOLDING SAND
GAS EVOLUTION AND HOT PERMEABILITY

Bond Clay Added	Percent Tempering Water	CC Gas Evolved per Gram of Sand					Cubic Feet Gas at 1,800° F. per Cubic Foot of Sand
		Gas from Dried Specimen			Steam 0	Total Gas	
		1/2 Minute	3 Minutes	7 Minutes	212° F.	1,800° F.	
Washed and Dried Silica Sand plus Bond Clays							
5% Western Bentonite	2.5	.50	2.50	2.50	40.0	43.3	233.8
4% Southern Bentonite	2.5	3.50	3.50	3.50	41.5	46.1	247.8
11% Ohio fireclay	3.5	3.00	3.00	3.00	56.5	60.3	824.8
Silica Sand Bonded with 5 Percent Western Bentonite and Other Binders							
1-10 Sea Coal (Vol.)	3.0	9.00	19.50	19.75	49.8	76.2	409.6
1-35 Pitch (Vol.)	2.9	4.25	7.50	7.50	48.2	58.2	312.8
1% Cereal Binder	3.4	7.25	9.50	9.50	56.5	69.0	370.9
1% Resin Binder	3.4	5.25	7.00	7.00	56.5	65.4	351.5
1% Special Binder A	3.5	4.25	7.00	7.00	58.0	67.3	381.6
1% Special Binder B	2.0	2.25	3.75	3.75	33.2	87.7	202.7
1% Dextrine	3.5	8.00	8.75	8.75	58.0	69.6	74.4
Silica Sands Bonded with 5 Percent Western Bentonite and 1-10 Sea Coal Volume							
Washed and dried Ottawa	8.0	9.00	19.50	19.75	49.8	76.2	409.6
Western Michigan core sand	2.9	5.00	15.25	15.25	48.2	68.4	367.7
Michigan bank sand	2.8	10.25	25.00	25.50	46.5	80.3	432.0
Gas Evolution from Sands in Actual Use							
Steel foundry-old sand	2.0	4.50	5.25	5.25	33.2	40.1	215.5
Steel foundry-facing sand	3.1	12.25	13.25	13.25	51.4	69.1	371.2
Malleable foundry-system sand	3.7	9.75	18.00	18.25	61.5	85.5	460.8
Malleable foundry-facing sand	3.8	18.25	27.75	27.75	63.0	99.4	534.4
Gray iron foundry-system sand	3.8	11.25	28.75	33.00	63.0	106.5	572.8
Synthetic Sand vs. Naturally Bonded Sand							
95% Washed and dried Ottawa	2.5	.50	2.50	2.50	40.0	43.3	232.3
5% Western Bentonite	4.8	9.00	11.00	11.00	78.0	93.3	502.4
New Albany sand	7.8	11.00	15.25	15.25	124.8	145.0	778.3

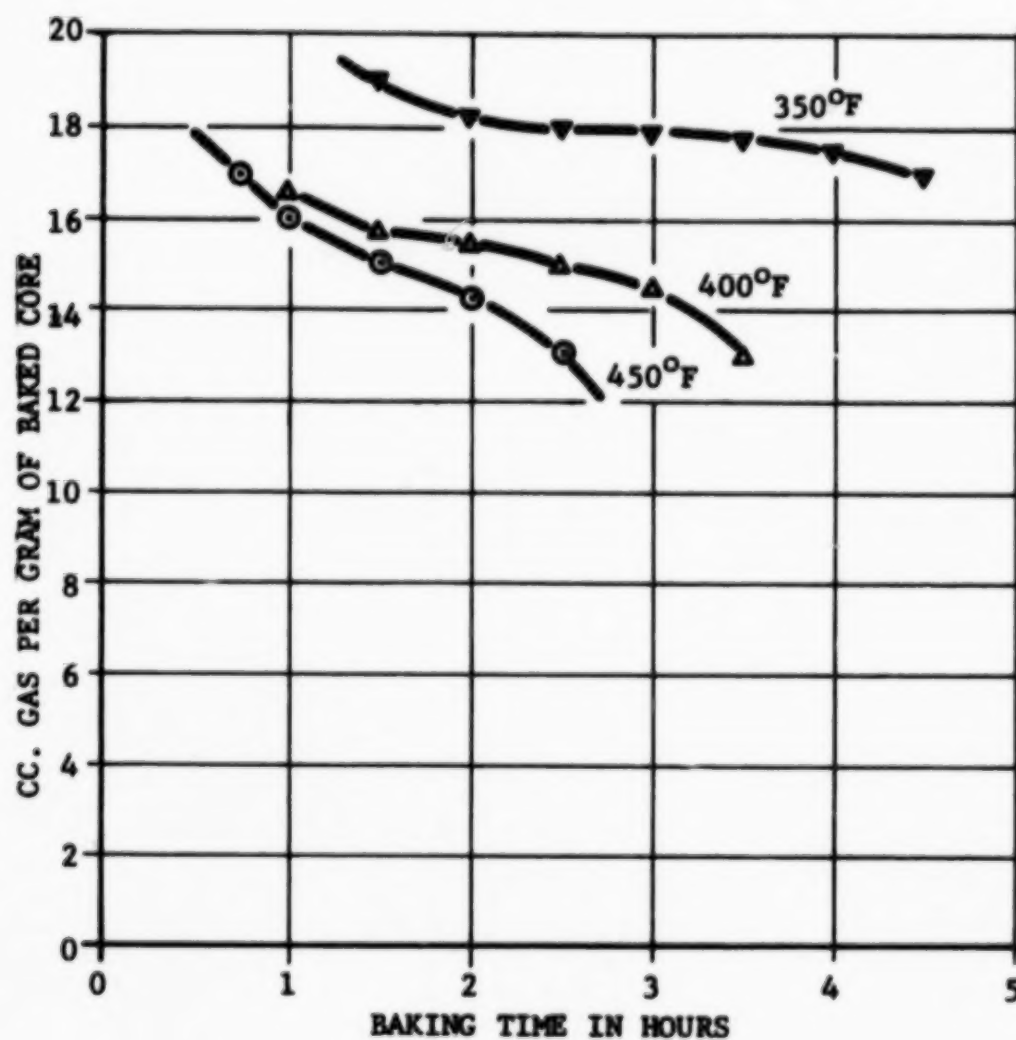
Source: "Gas Developed in Molds," Dumbeck, Foundry, September, 1944.

GAS VOLUME EVOLVED AS A
FUNCTION OF VOLATILES
CONTAINED IN MOLDING SAND

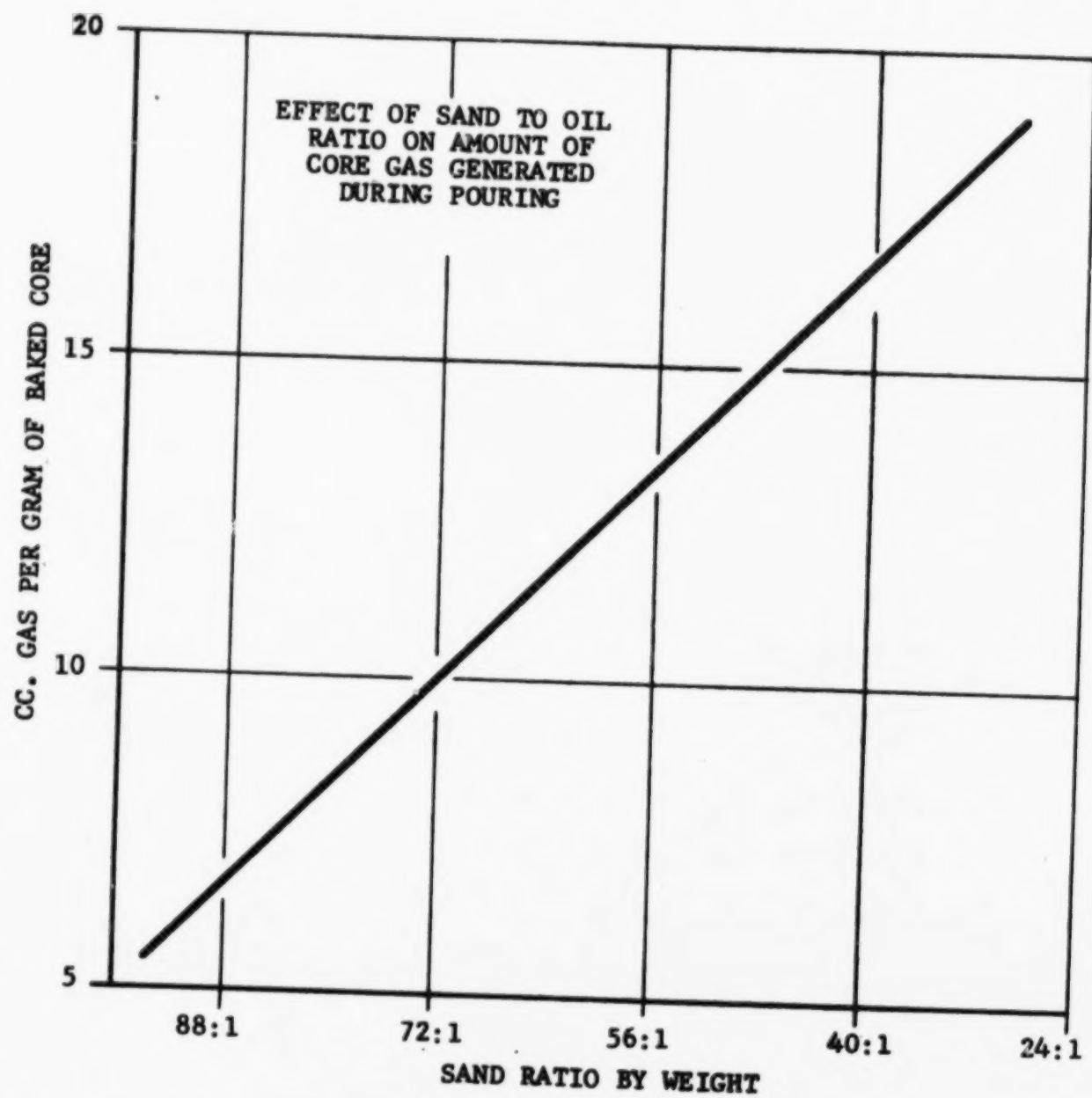


Note: Adapted from an article by F. Hoffman, "Property Changes and Conditioning of Repeatedly Circulating Foundry Sand Systems," Modern Casting, October, 1967.

EFFECT OF BAKING TIME ON
GAS GENERATED DURING POURING
FOR VARIOUS BAKING TEMPERATURES

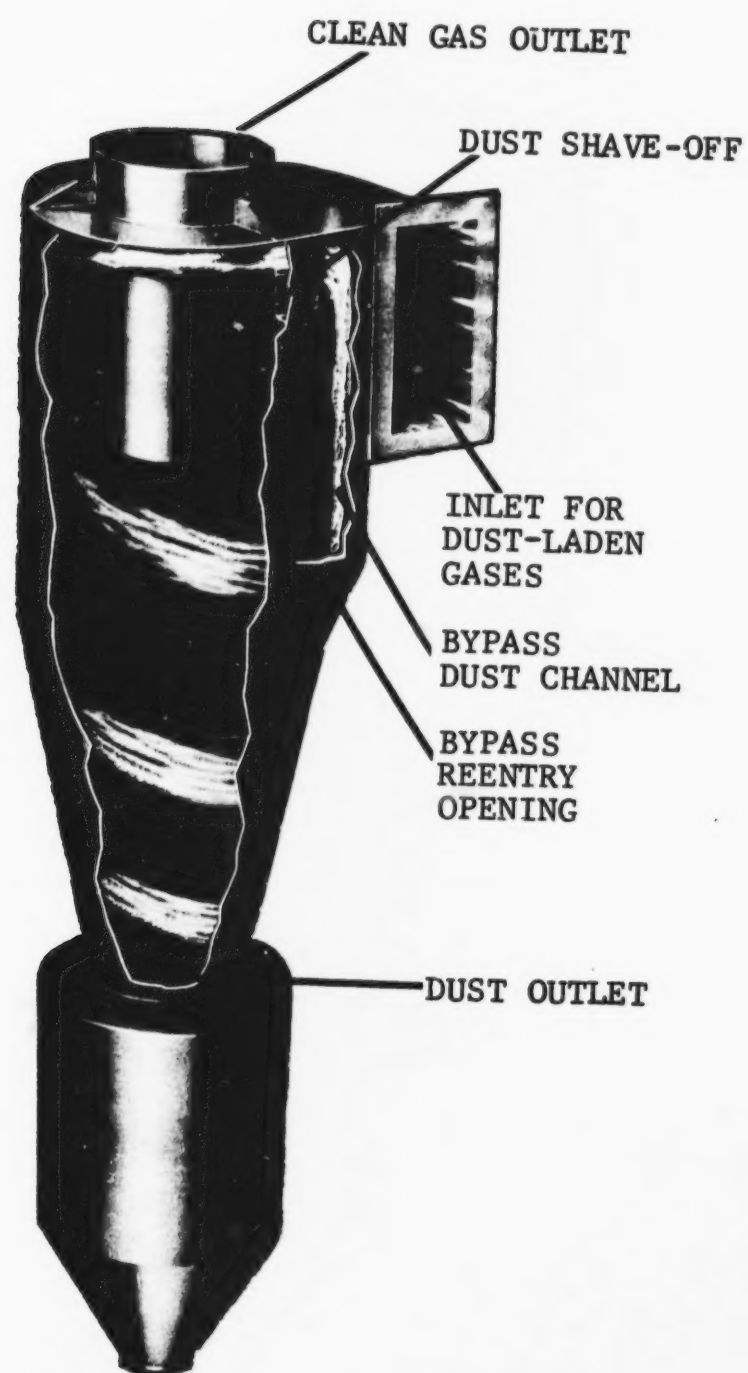


Note: Adapted from Foundry Core Practice by
H. Dietert, 1966, p. 172.



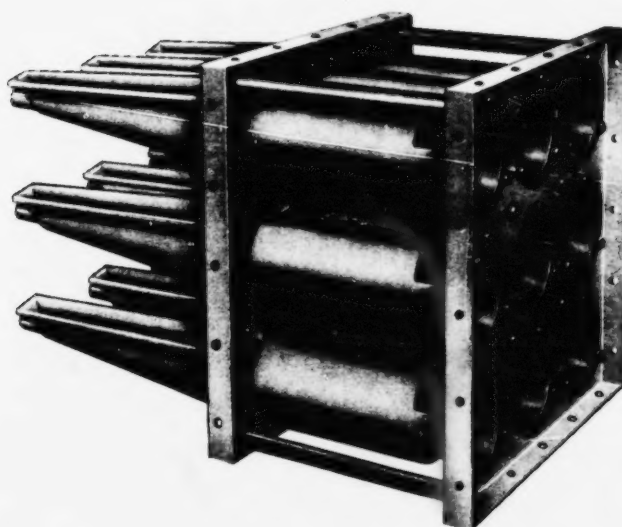
Source: Foundry Core Practice, H. Dietert, 1966.

CYCLONE COLLECTOR



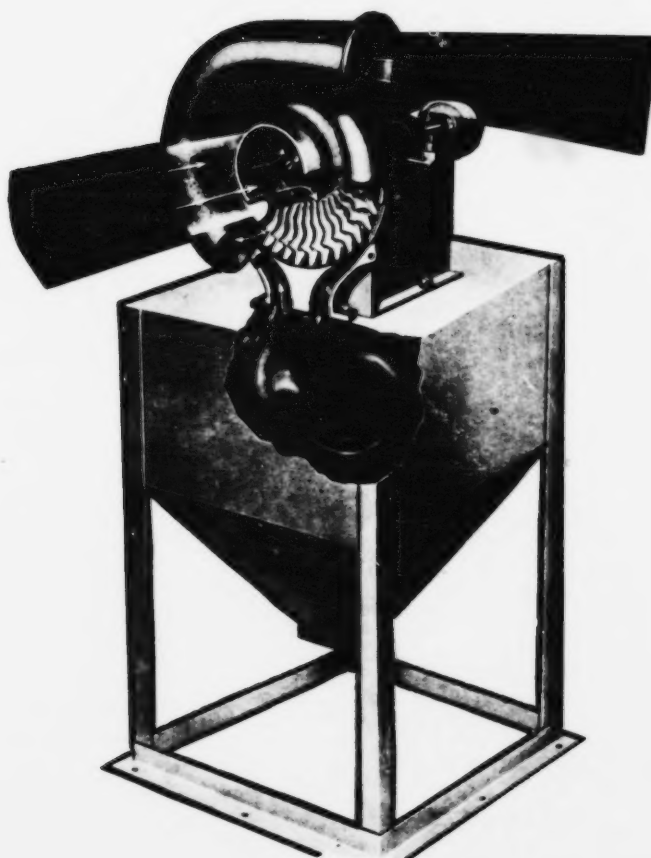
Source: Buell Engineering Company.

HIGH EFFICIENCY CENTRIFUGAL COLLECTOR



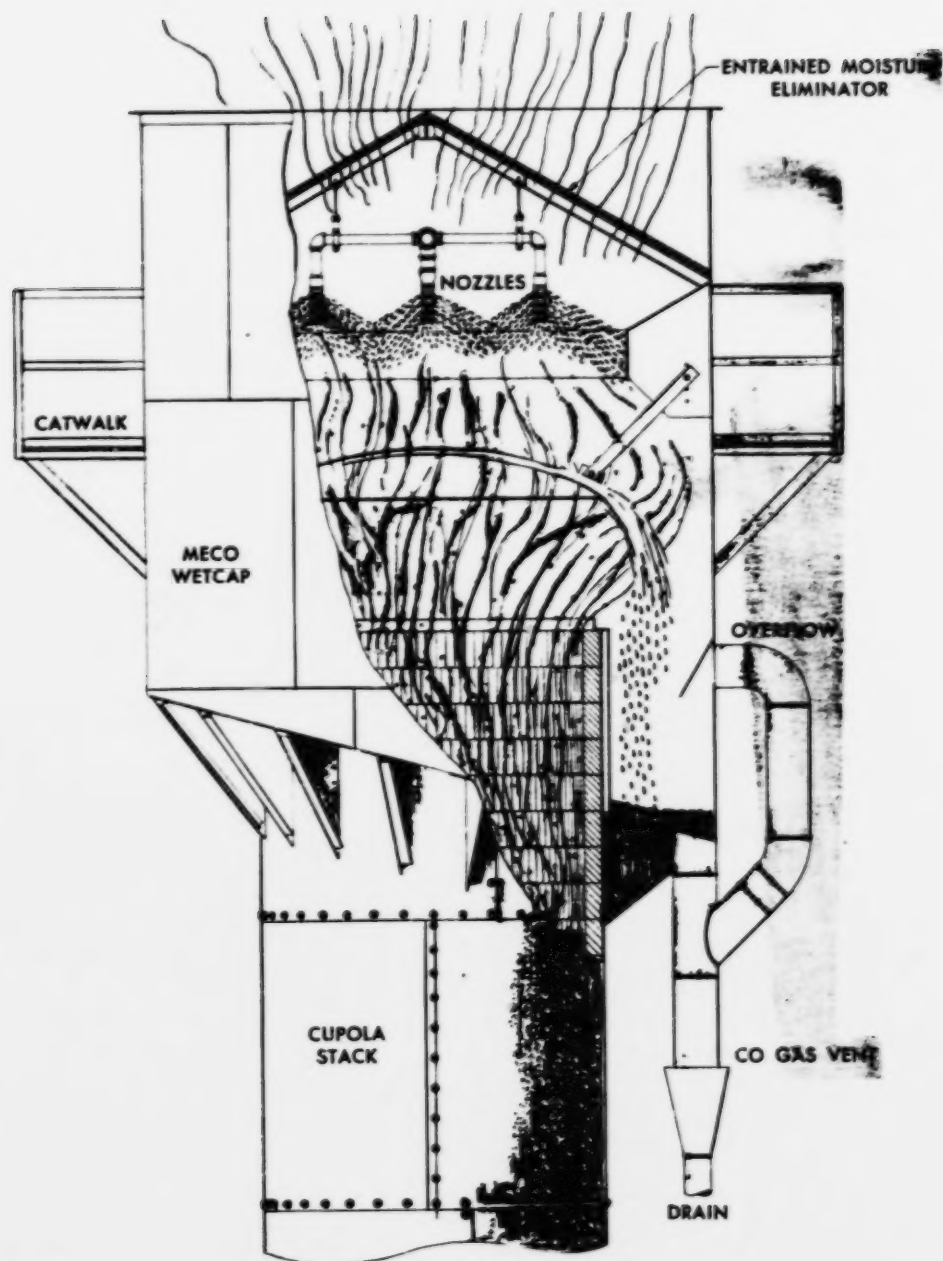
Source: American Air Filter.

DRY DYNAMIC PRECIPITATOR COLLECTOR



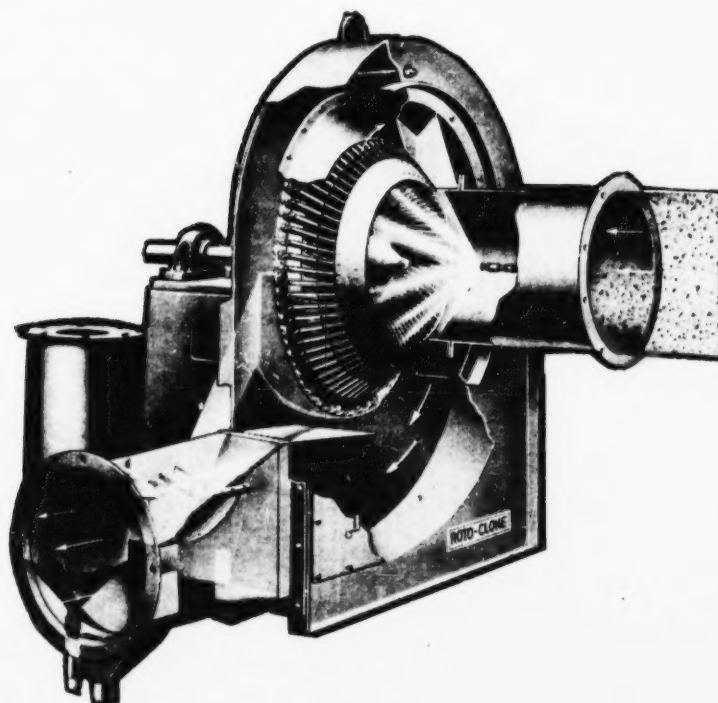
Source: American Air Filter.

WET CAP COLLECTOR



Source: Modern Equipment Company.

WET DYNAMIC PRECIPITATOR COLLECTOR



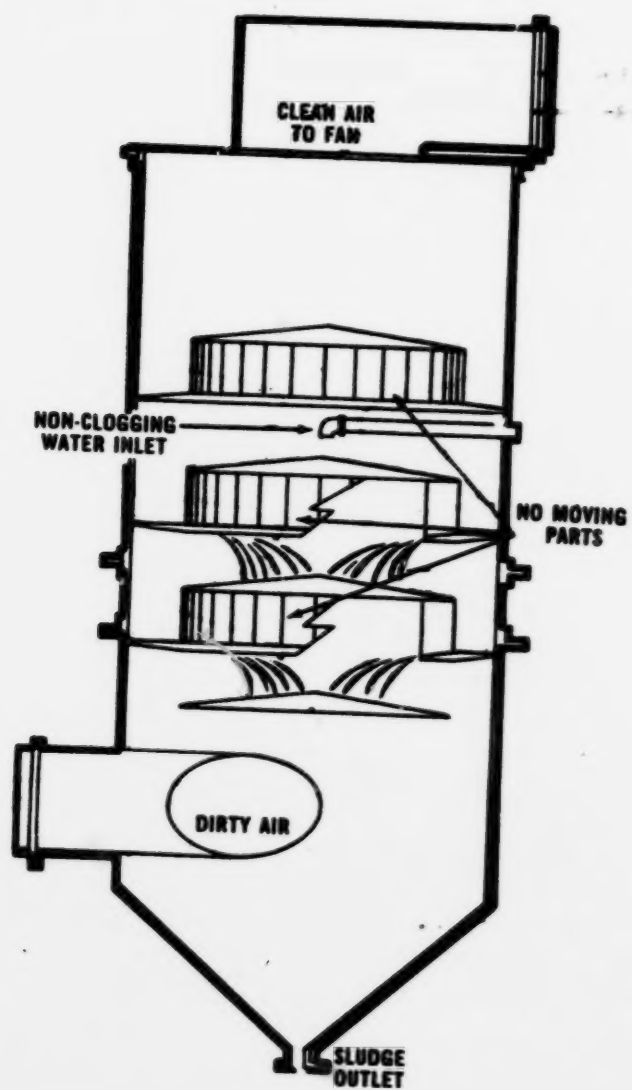
Source: American Air Filter.

VANE-TYPE CENTRIFUGAL
WET COLLECTOR



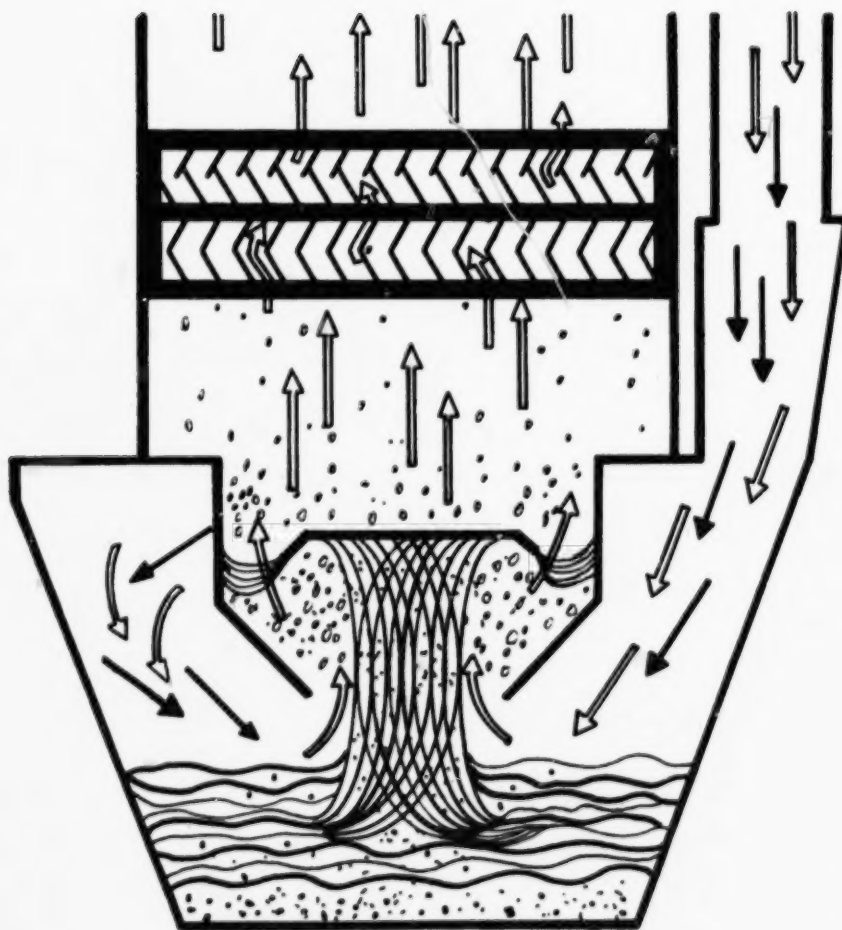
Source: Dust Collectors, American Foundrymen's Society.

MULTIPLE TUBE-TYPE CENTRIFUGAL
WET COLLECTOR



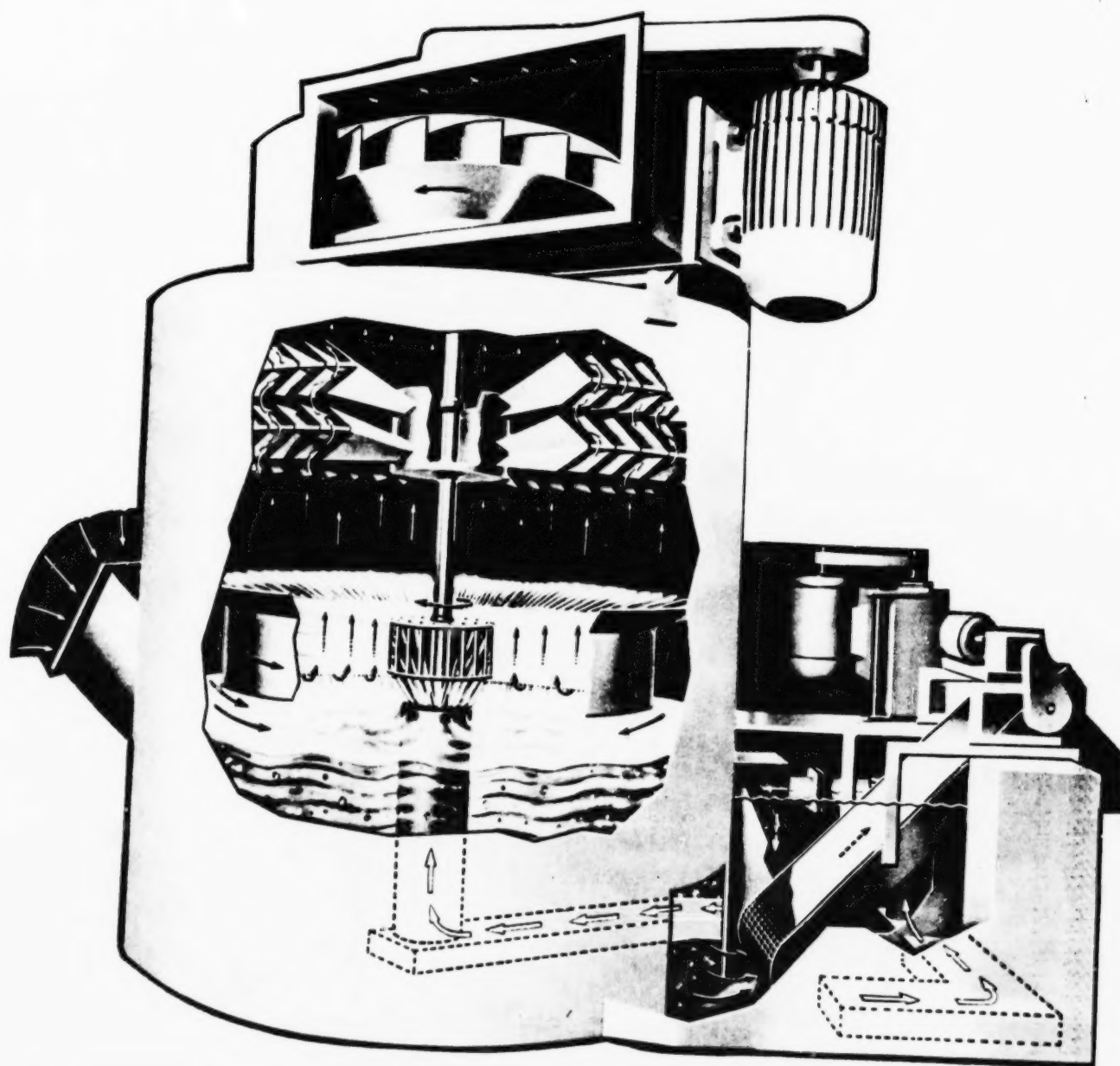
Source: American Air Flow Corporation.

ORIFICE-TYPE WET COLLECTOR



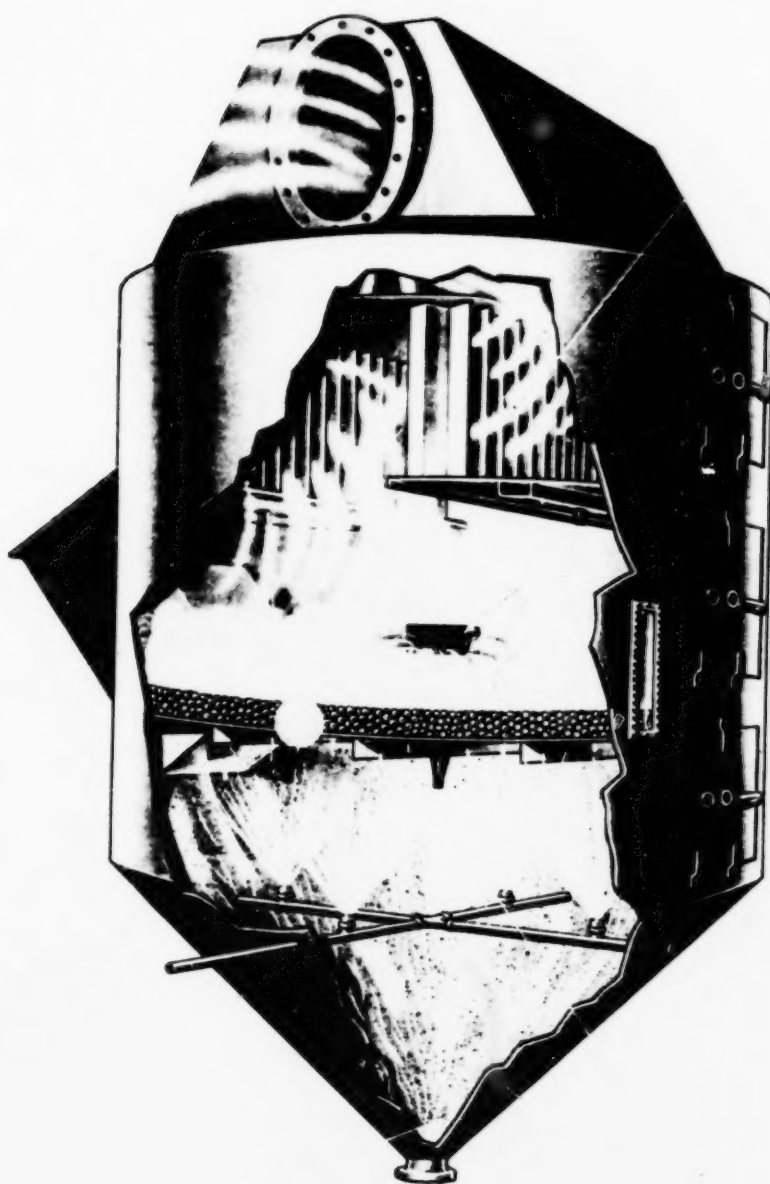
Source: The De Vilbiss Company.

CENTRIFUGAL SPRAY WET COLLECTOR



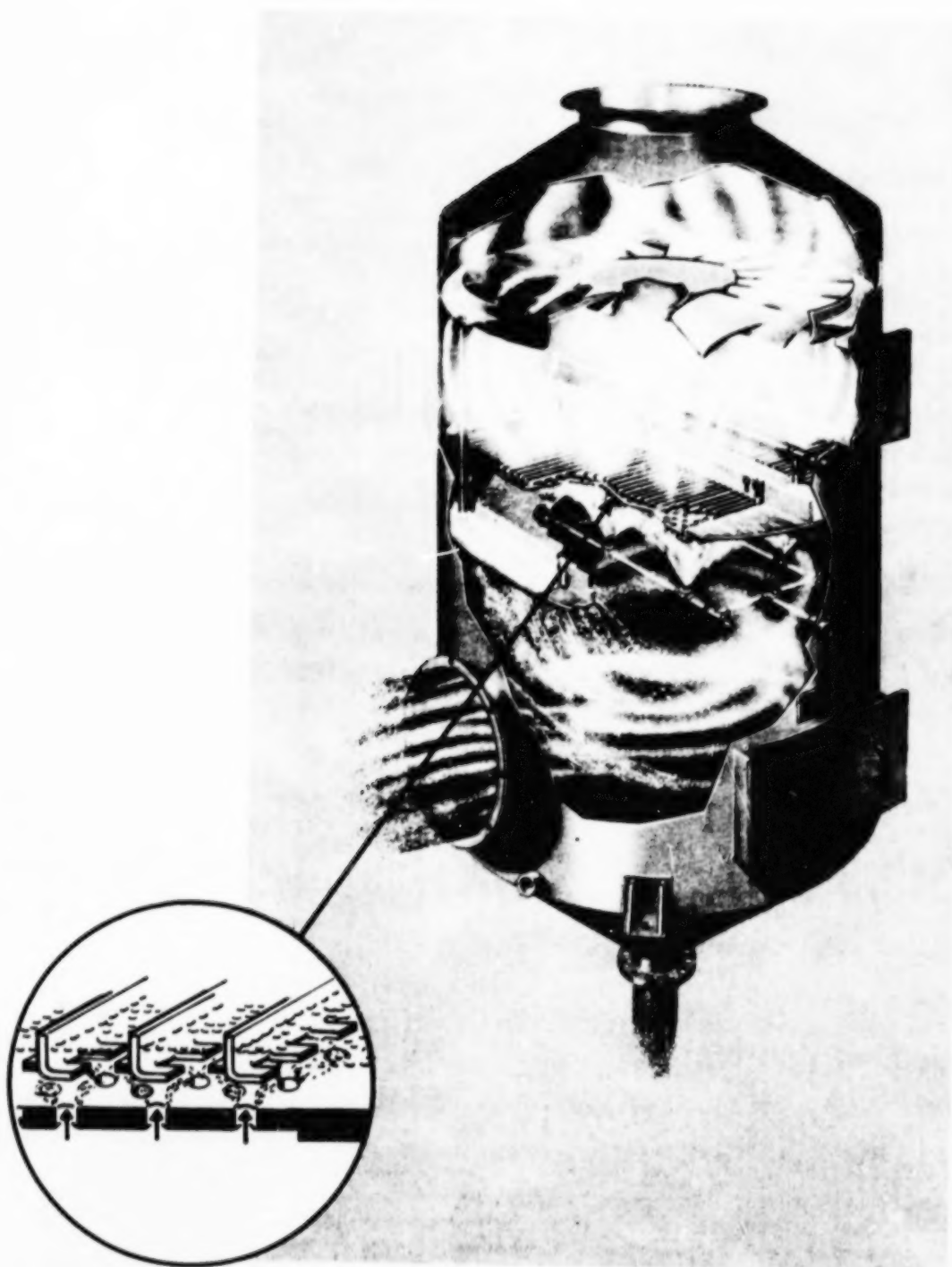
Source: Centri-Spray Corporation.

MARBLE BED-TYPE WET COLLECTOR



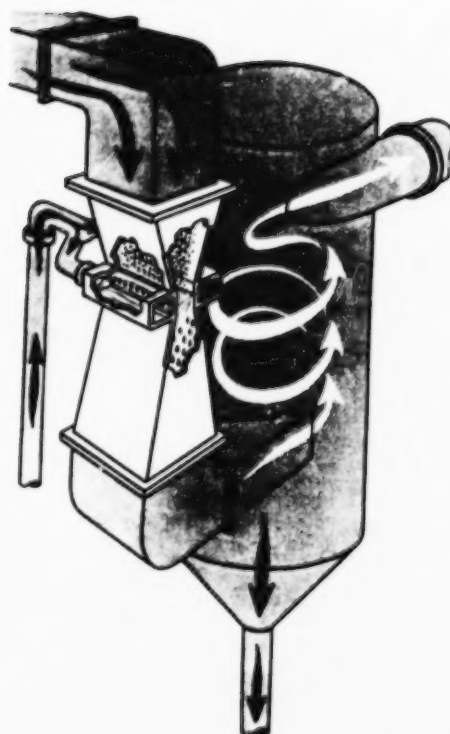
Source: National Dust Collector Corporation.

IMPINGEMENT BAFFLE GRID-TYPE
WET COLLECTOR



Source: Arco Ind.

VENTURI COLLECTOR



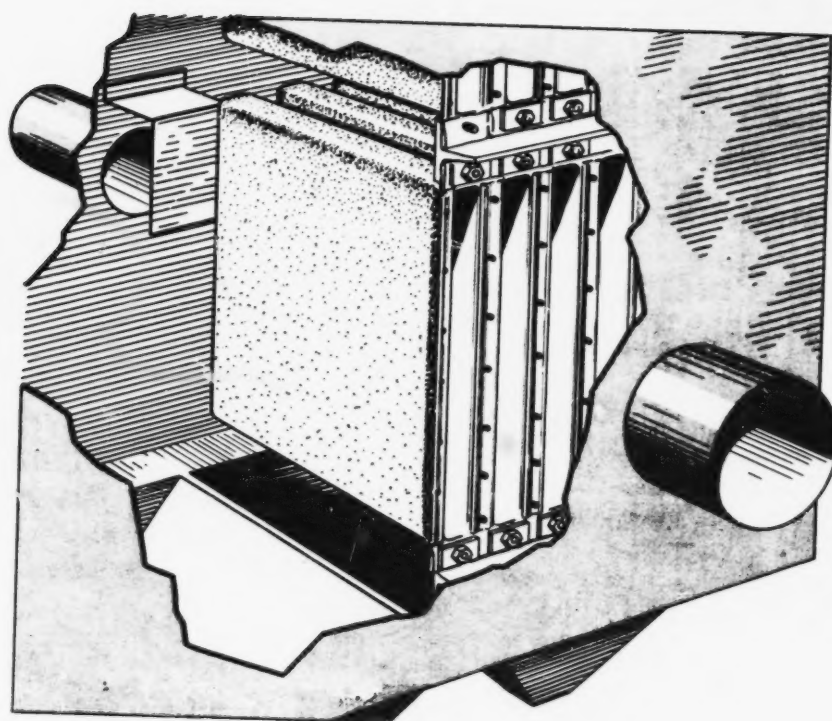
Source: Chemical Construction Co.

WET COLLECTOR PARTICLE COLLECTION
LIMITATIONS AND DESIGN CAPACITIES

<u>Control Equipment Type</u>	<u>Relative Comparison of Smallest Particle Collected (Microns)</u>	<u>Range of Capacities Available in Cubic Feet/Minute</u>	
		<u>Low</u>	<u>High</u>
Static Washer	10	500	100,000
Dynamic Precipitator	2 to 3	1,000	50,000
Centrifugal	2 to 5	575	108,000
Orifice	2	400	50,000
Centrifugal Spray	2	300	50,000
Flooded Bed	2	1,000	500,000
Venturi	0.5	5,000	50,000

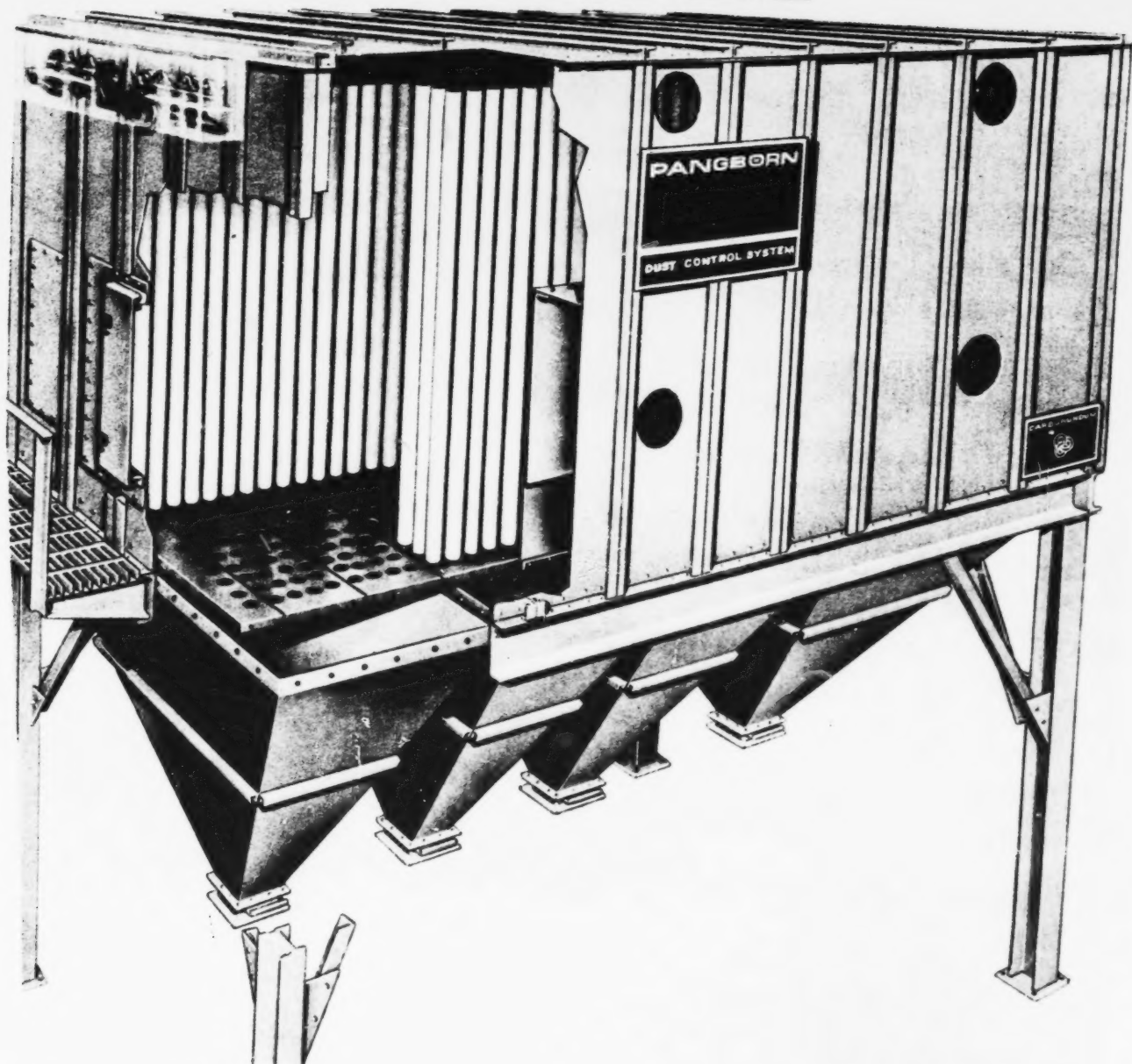
Source: Dust Collectors, American Foundrymen's Society.

CUTAWAY VIEW SHOWING
FABRIC FILTER, FLAT- OR
SCREEN-TYPE BAG



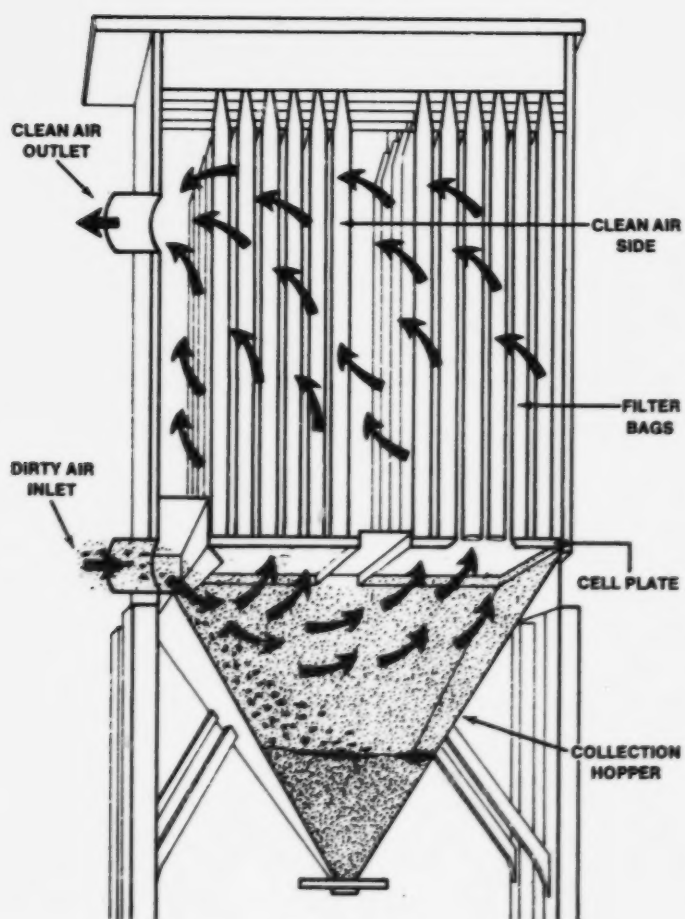
Source: Sly Manufacturing Company.

CUTAWAY VIEW SHOWING
FABRIC FILTER TUBULAR-TYPE BAGS



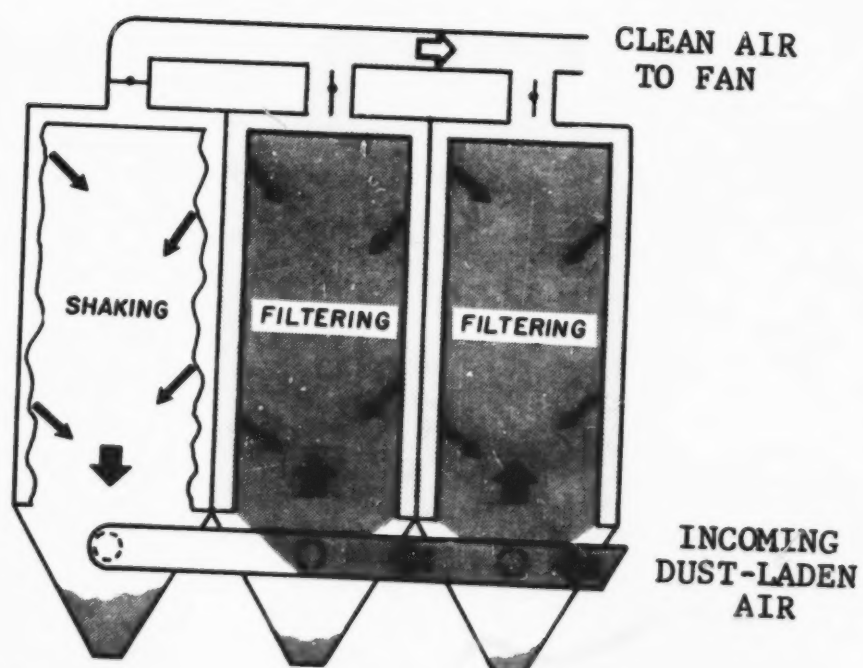
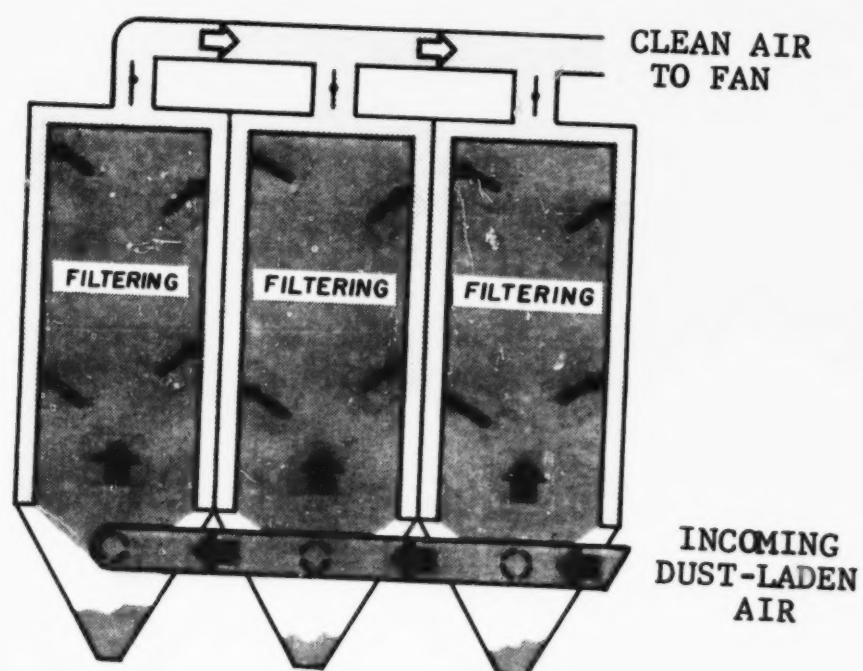
Source: Pangborn Division, Carborundum Company.

INTERMITTENT FABRIC FILTER COLLECTOR



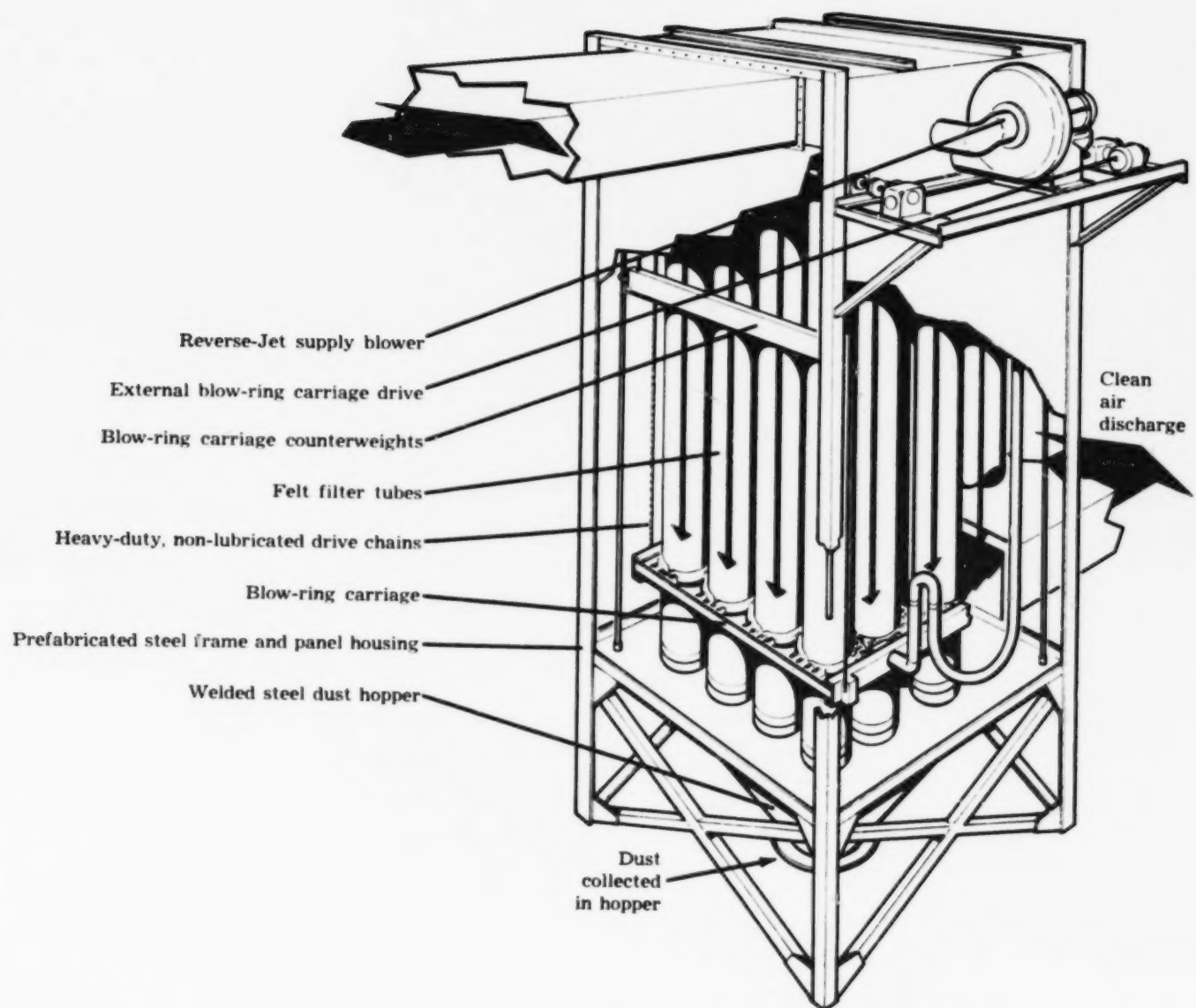
Source: Burlington Glass Fabrics.

CONTINUOUS AUTOMATIC FABRIC FILTER COLLECTOR



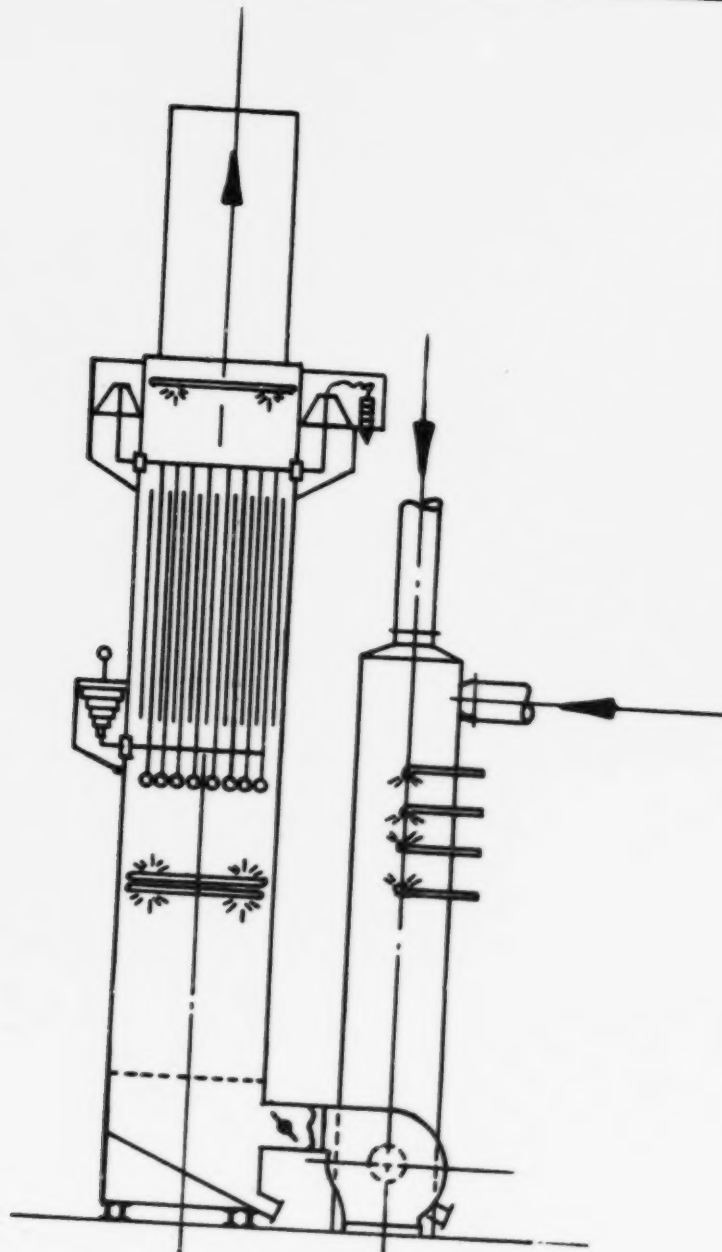
Source: Fuller Company.

REVERSE JET CONTINUOUS FABRIC FILTER COLLECTOR



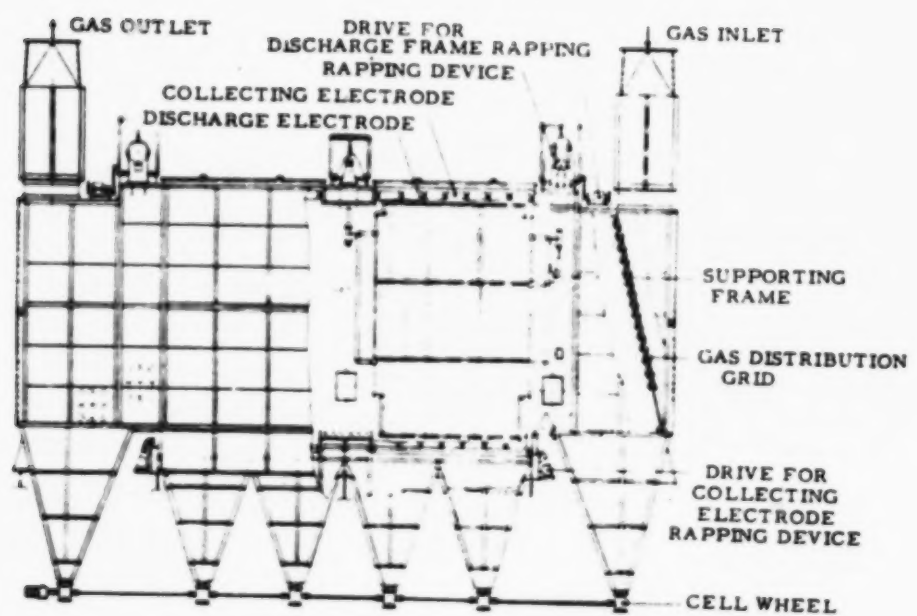
Source: Buffalo Forge Company.

WET-TYPE ELECTROSTATIC PRECIPITATOR
EFFLUENT CLEANING SYSTEM



Source: Cupola Emission Control, Gray & Ductile Iron Society.

DRY-TYPE ELECTROSTATIC PRECIPITATOR
EFFLUENT CLEANING SYSTEM



Source: Cupola Emission Control, Gray & Ductile Iron Society.

COLLECTION EFFICIENCY OF EMISSION CONTROL EQUIPMENT SYSTEMS

Foundry Application	Particle Size	Typical Inlet Loading Gr/SCF	Typical Outlet Loading Gr/SCF			
			Wet Cap	Wet Scrubber 6"-30"	Efficiency Cyclone 30"-70"	Fabric Filter Electrostatic Precipitator
<u>Melting</u>						
Gray Iron Cupola	Coarse to Fine	1/2-10	0.4	0.3	0.05	0.01
Electric Arc	Fine	1/2-2	X	0.2	0.02	0.01
Screens and Transfer Points	Medium	1/2-3	X	0.005-0.01	X	0.01
Dry Sand Reclaimer	Coarse to Fine	10-40	X	0.1	0.02-0.05	0.01
Sand Cooler	Medium	1-20	X	0.01-0.05	X	X
Abrasive Cleaning	Fine to Coarse	1/2-5	X	0.01-0.05	X	0.01
Grinding	Coarse to Medium	1/2-2	X	0.01	X	0.01
Shakeout	Fine to Medium	1/2-1	X	0.01	X	X

Note: Particle Size

Coarse +20 Microns
Medium 2-20 Microns
Fine -2 Microns

X = Not applicable or rarely used.

Underlined outlet loading is lowest for that application.

Sources: Foundry Air Pollution Control Manual, American Foundrymen's Society;
Air Pollution Engineering Manual, U.S. Department of Health, Education and Welfare, #999-AP-40.

EXHIBIT VII-21

GRADING OF TEST DUST

<u>Size of Grade, Microns</u>	<u>Percentage by Weight in Grade</u>	<u>Percentage by Weight Smaller Than Top Size of Grade</u>
104-150	3%	100
75-104	7	97
60-75	10	90
40-60	15	80
30-40	10	65
20-30	10	55
15-20	7	45
10-15	8	38
7½-10	4	30
5-7½	6	26
2½-5	8	20
Under 2½	<u>12</u>	12
Total	<u>100%</u>	

Source: Design & Performance of Modern Gas Cleaning Equipment, Journal of the Institute of Fuel, February, 1956.

OVERALL COLLECTION EFFICIENCY ON TEST DUST

<u>Apparatus</u>	<u>Overall Efficiency Percent</u>	<u>Efficiency at 5 Microns Percent</u>	<u>Efficiency at 2 Microns Percent</u>	<u>Efficiency at 1 Micron Percent</u>
Medium efficiency cyclone	65.3%	27%	14%	8%
High efficiency cyclone	84.2	73	46	27
Fabric filter	99.9	>99.9	99.9	99
Spray tower	96.3	94	87	55
Wet impingement scrubber	97.9	97	92	80
Self-induced spray deduster	93.5	93	75	40
Venturi scrubber	99.7	99.6	99	97
Electrostatic precipitator	94.1	92	85	70

Source: Design & Performance of Modern Gas Cleaning Equipment, Journal of the Institute of Fuel, February, 1956.

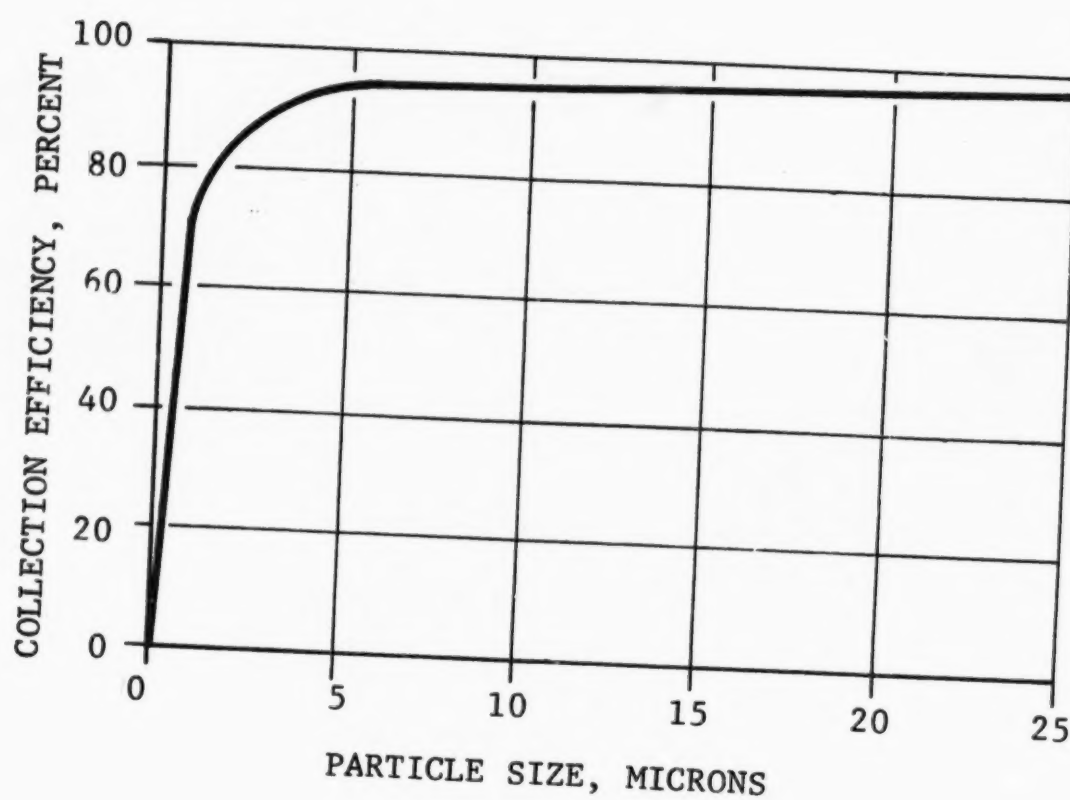
CHEMICAL COMPOSITION OF CUPOLA DUST BY WEIGHT

	<u>Mean Range</u>	<u>Scatter Values</u>
SiO ₂	20%-40%	10%-45%
CaO	3-6	2-18
Al ₂ O ₃	2-4	0.5-25
MgO	1-3	0.5-5
FeO (Fe ₂ O ₃ , Fe)	12-16	5-26
MnO	1-2	0.5-9
Ignition Loss (C, S, CO ₂)	20-50	10-64

Source: Cupola Emission Control, Gray & Ductile Iron
Founders' Society, Inc.

GRADE EFFICIENCY CURVE

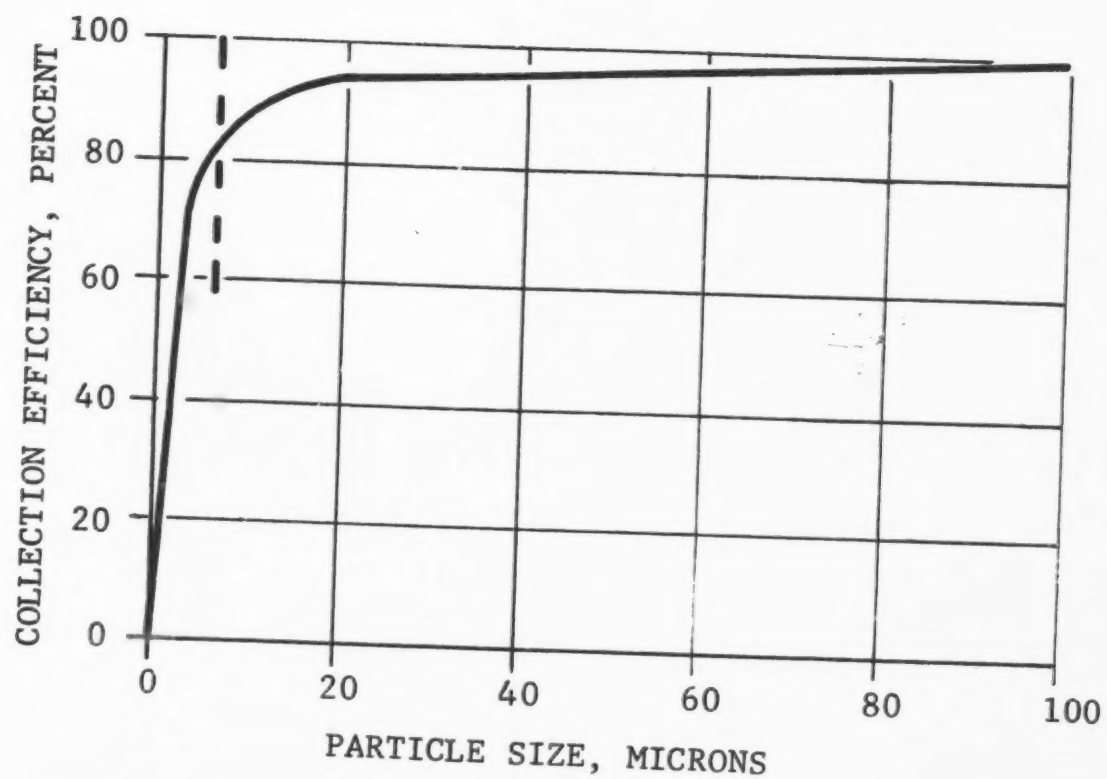
DRY
ELECTROSTATIC
PRECIPITATOR



Source: Design and Performance of Modern Gas Cleaning Equipment, Journal of the Institute of Fuel, February, 1956.

GRADE EFFICIENCY CURVE

HIGH
EFFICIENCY
CYCLONE

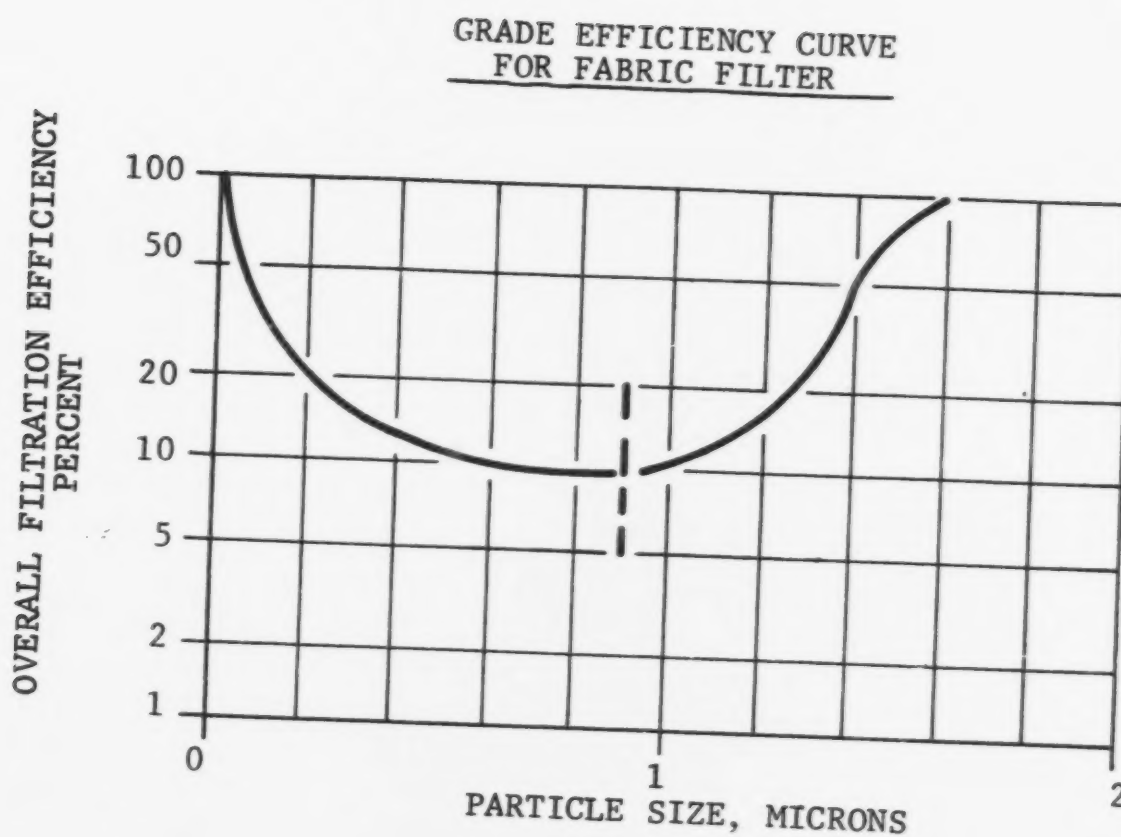


Source: Design and Performance of Modern Gas Cleaning Equipment, Journal of the Institute of Fuel, February, 1956.

CALCULATION OF COLLECTOR EFFICIENCY

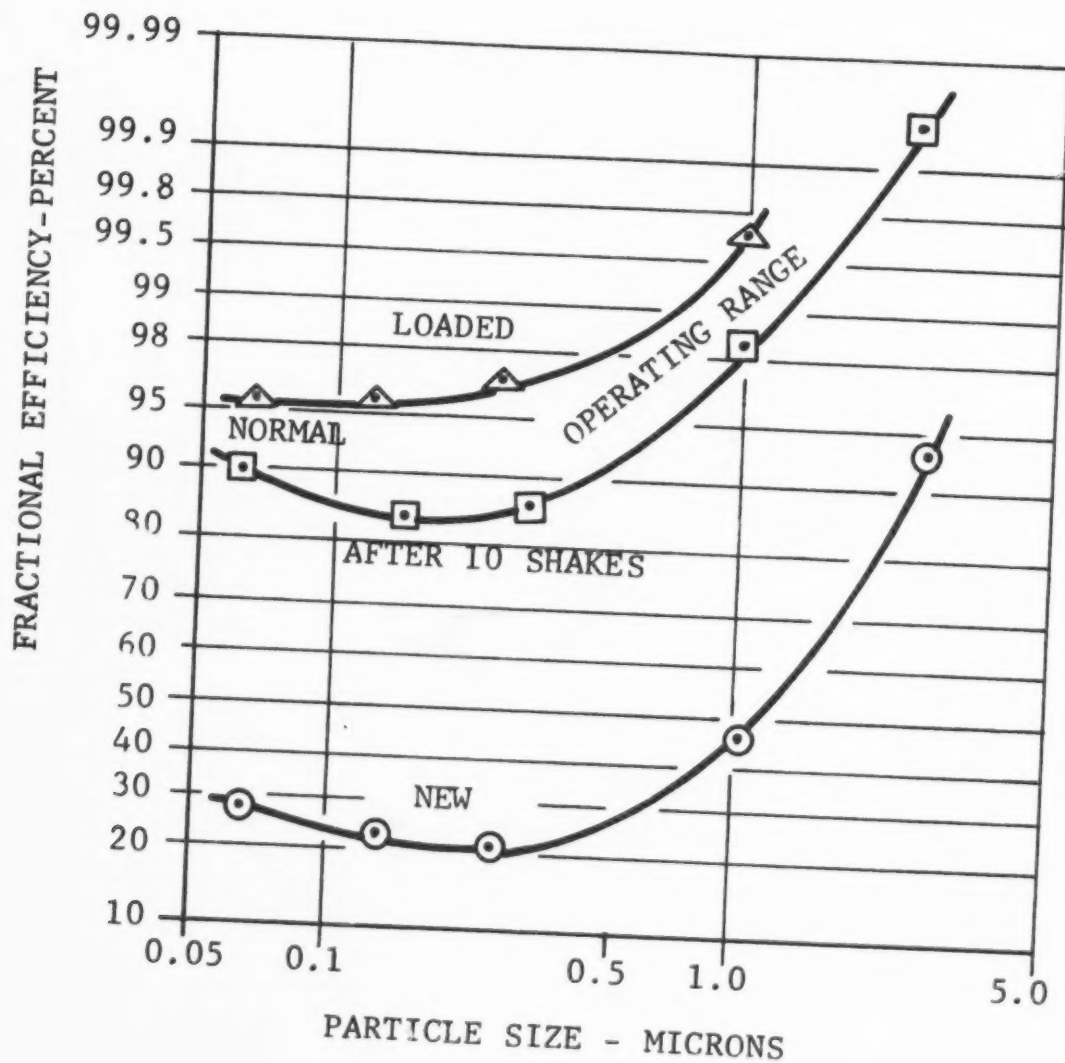
Cyclone			Electrostatic Precipitator		
Size of Grade, Microns	Percent in Grade at Inlet	Efficiency at Mean Size of Grade, Percent		Overall Collection, Percent	
		Percent in Grade at Inlet	at Mean Size of Grade, Percent		
104-150	3%	100.0%	104-150	-	
75-104	7	99.1	75-104	0.6%	
60-75	10	98.5	60-75	0.6	
40-60	15	97.3	40-60	2.5	
30-40	10	96.0	30-40	2.5	
20-30	10	94.3	20-30	3.8	
15-20	7	92.0	15-20	3.8	
10-15	8	89.3	10-15	5.7	
7½-10	4	84.2	7½-10	3.8	
5-7½	6	76.7	5-7½	8.8	
2½-5	8	64.5	2½-5	17.6	
0-2	12	33.5	0-2½	50.3	
		Total		Total	
				85.4%	

Source: Design and Performance of Modern Gas Cleaning Equipment, Journal of the Institute of Fuel, February, 1956.



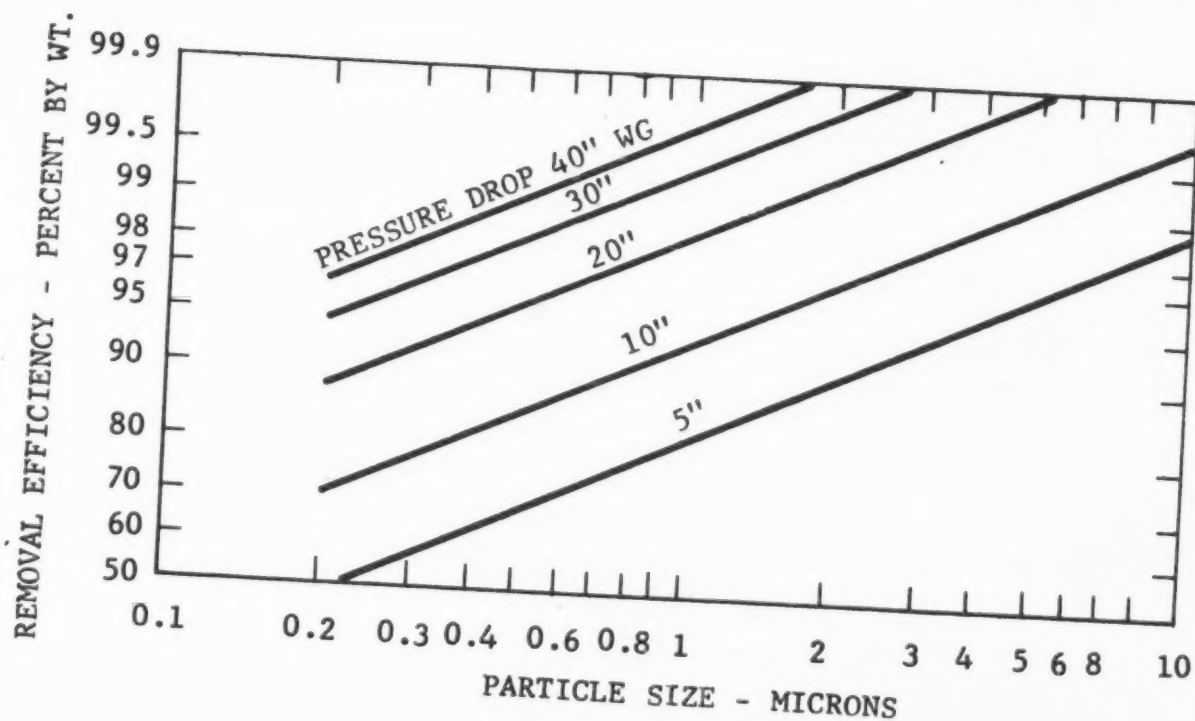
Source: Design and Performance of Modern Gas Cleaning Equipment, Journal of the Institute of Fuel, February, 1956.

EFFECT OF PARTICLE SIZE AND LENGTH OF
BAG IN SERVICE ON FABRIC FILTER EFFICIENCY



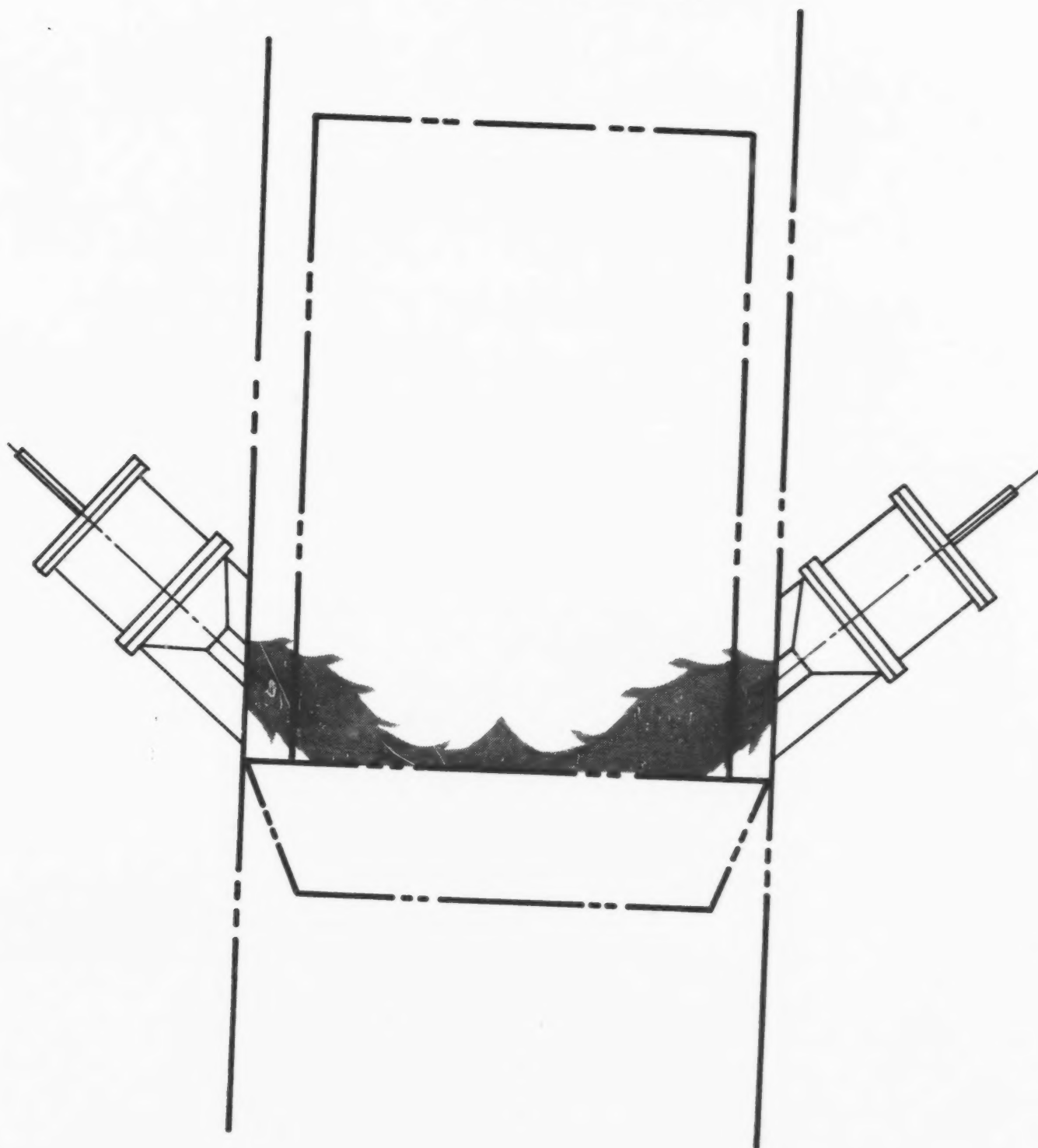
Source: Torit, Dust Collectors, January, 1966.

RELATIONSHIP BETWEEN COLLECTION EFFICIENCY,
PARTICLE SIZE AND PRESSURE DROP FOR VENTURI SCRUBBERS



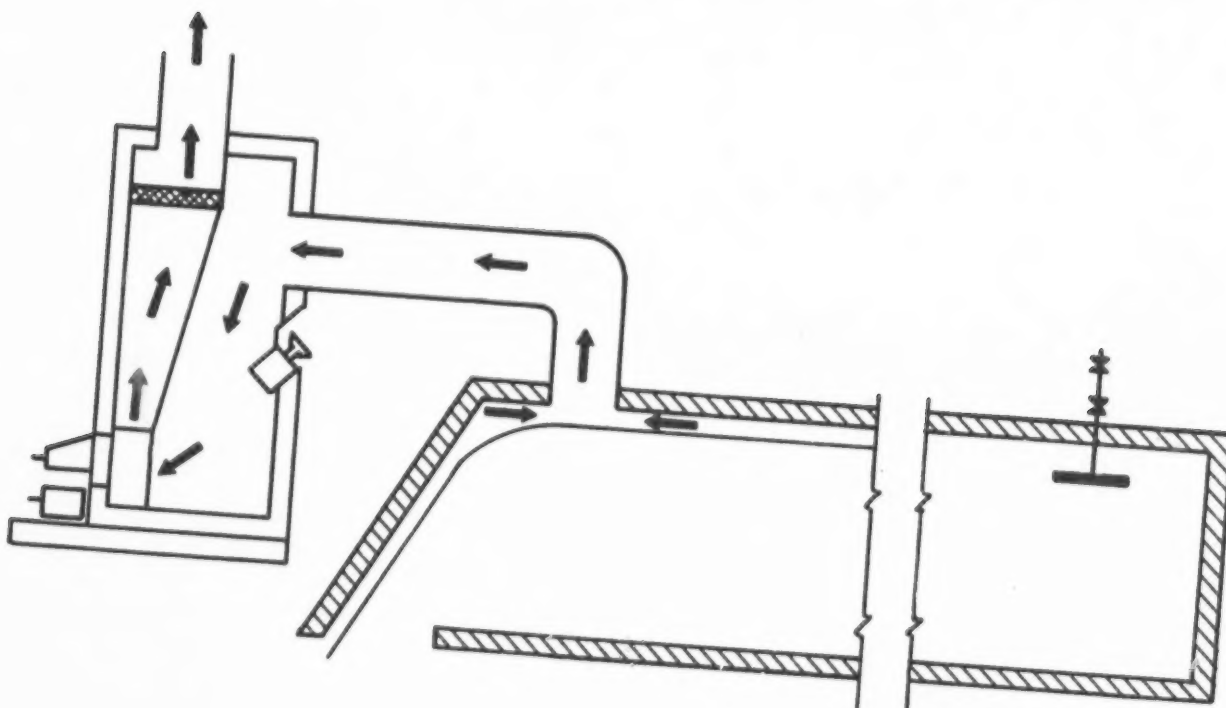
Source: Air Pollution Manual, American Industrial Hygiene Association.

CUPOLA AFTERBURNER



Source: Foundry Air Pollution Control Manual, AFS.

CATALYTIC AFTERBURNER APPLIED
TO CORE BAKE OVEN PROCESS



Source: Air Pollution Engineering Manual, U.S. Department
of Health, Education and Welfare, #999-AP-40.

APPLICATION OF EMISSION CONTROL EQUIPMENT SYSTEM

Foundry Process	Dry Mechanical		Wet Scrubber				
	Low Pressure Loss Cyclone	Medium Pressure Loss	Low Pressure Loss (Wet Cap)	Medium Pressure Loss "4-8"	Intermediate Pressure Loss "9-20"	High Pressure Loss "21-80"	
Raw Material Handling and Preparation	No	Rare	No	Rare	No	No	Rare
<u>Melting Processes</u>							
Cupola	Rare	Frequently	Frequently	Frequently	Frequently	Frequently	No
Electric Arc	No	No	No	No	Rare	Occasionally	Rare
Electric Induction	No	No	No	No	No	No	No
Inoculation	No	No	No	Rare	Rare	Rare	Occa
Mold Pouring & Cooling	No	No	No	Rare	No	No	No
<u>Shakeout</u>							
Enclosed Hood	Rare	Occasionally	No	Usual	Occasionally	No	Occa
Side Hood	No	Rare	No	Usual	Occasionally	No	Occa
<u>Sand Preparation & Handling</u>							
Shakeout Molding Sand	Rare	Occasionally	No	Usual	Rare	No	Rare
New Sand	Rare	Occasionally	No	Usual	Rare	No	Occa
Core Sand	Rare	Occasionally	No	Usual	Rare	No	Occa
<u>Coremaking</u>							
Mechanical Material Handling	Rare	Rare	No	Frequently	No	No	Freq
Pneumatic	No	No	No	Rare	No	No	Usua
Bake Oven	No	No	No	No	No	No	No
Grinding	Rare	Occasionally	No	Frequently	No	No	Freq
<u>Casting Cleaning</u>							
Airless Abrasive	No	Rare	No	Frequently	No	No	Usua
Blast Rooms	No	Rare	No	Usual	?	No	Usua
Tumbling Mills	No	Rare	No	Usual	?	No	Usua
Sprue	No	Occasionally	No	Usual	?	No	Usua
<u>Grinding</u>							
Snagging	Frequently	Frequently	No	Frequently	No	No	Freq
Swing Frame	Rare	Frequently	No	Frequently	No	No	Freq
Portable	Rare	Frequently	No	Usual	No	No	Usua
<u>Boiler Fly Ash</u>							
Chain Grate	No	Occasionally	No	No	No	No	No
Spreader Stoker	No	Usual	No	No	No	No	No
Pulverizer	No	Usual	No	No	No	No	No
Paint Ovens	No	No	No	No	No	No	No
Oil Burn-off Furnaces	No	No	No	Rare	No	No	No
<u>Pattern Shop</u>							
Wood	Usual	Rare	No	Rare	No	No	Occa
Metal	Frequently	Usual	No	Rare	No	No	Occa

Sources: Foundry Air Pollution Control Manual, American Foundrymen's Society, 1967.
 American Air Filter, Dust Collector Selection Guide, Bulletin 268-A, October, 1966.
 Personal notes of John Kane.

A

EMISSION CONTROL EQUIPMENT SYSTEMS TO FOUNDRY PROCESSES

Rubber Intermediate Pressure Loss "9-20"	High Pressure Loss "21-80"	Fabric Filter				Electrostatic Precipitator		Catalytic Combustion
		Cotton or Wool	Orlon or Dacron	Nomex	Glass	Dry	Wet	
No	No	Rare	No	No	No	No	No	No
Frequently Rare No	Frequently Occasionally No	No Rare No	Rare Usual No	Occasionally Rare No	Frequently No No	Rare Rare No	No No No	No No No
Rare	Rare	Occasionally	Rare	Rare	No	No	No	No
No	No	No	No	No	No	No	No	No
Occasionally Occasionally	No No	Occasionally Occasionally	No No	No No	No No	No No	No No	No No
Rare Rare Rare	No No No	Rare Occasionally Occasionally	No No No	No No No	No No No	No No No	No No No	No No No
No No No No	No No No No	Frequently Usual No Frequently	No No No No	No No No No	No No No No	No No No No	No No No No	No No Frequently No
No ? ? ?	No No No No	Usual Usual Usual Usual	No No No No	No No No No	No No No No	No No No No	No No No No	No No No No
No No No	No No No	Frequently Frequently Usual	No No No	No No No	No No No	No No No	No No No	No No No
No No No	No No No	No No No	No No No	No No No	No No No	No No Frequently	No No No	No No No
No	No	No	No	No	No	No	No	Frequently
No	No	No	No	No	No	No	No	Frequently
No No	No No	Occasionally Occasionally	No No	No No	No No	No No	No No	No No

B

CONDITIONS AFFECTING INSTALLATION COST OF CONTROL DEVICES

<u>Cost Category</u>	<u>Low Cost</u>	<u>High Cost</u>
Equipment Transportation	Minimum distance; simple loading and unloading procedure	Long distance; complex procedure for loading and unloading
Plant Age	Hardware designed as an integral part of new plant	Hardware installed into confines of old plant requiring structural or process modification or alternation
Available space	Vacant area for location of control system	Little vacant space requires extensive steel support construction and site preparation
Corrosiveness of gas	Noncorrosive gas	Acidic emissions requiring high alloy accessory equipment using special handling and construction techniques
Complexity of start-up	Simple start-up no extensive adjustment required.	Requires extensive adjustment; testing considerable downtime
Instrumentation	Little required	Complex instrumentation required to assure reliability of control or constant monitoring of gas stream
Guarantee on performance	None needed	Required to assure designed control efficiency
Degree of assembly	Control hardware shipped completely assembled	Control hardware to be assembled and erected in the field
Degree of engineering	Autonomous "package" control system	Control System requiring extensive integration into process, insulation to correct temperature problem and noise abatement

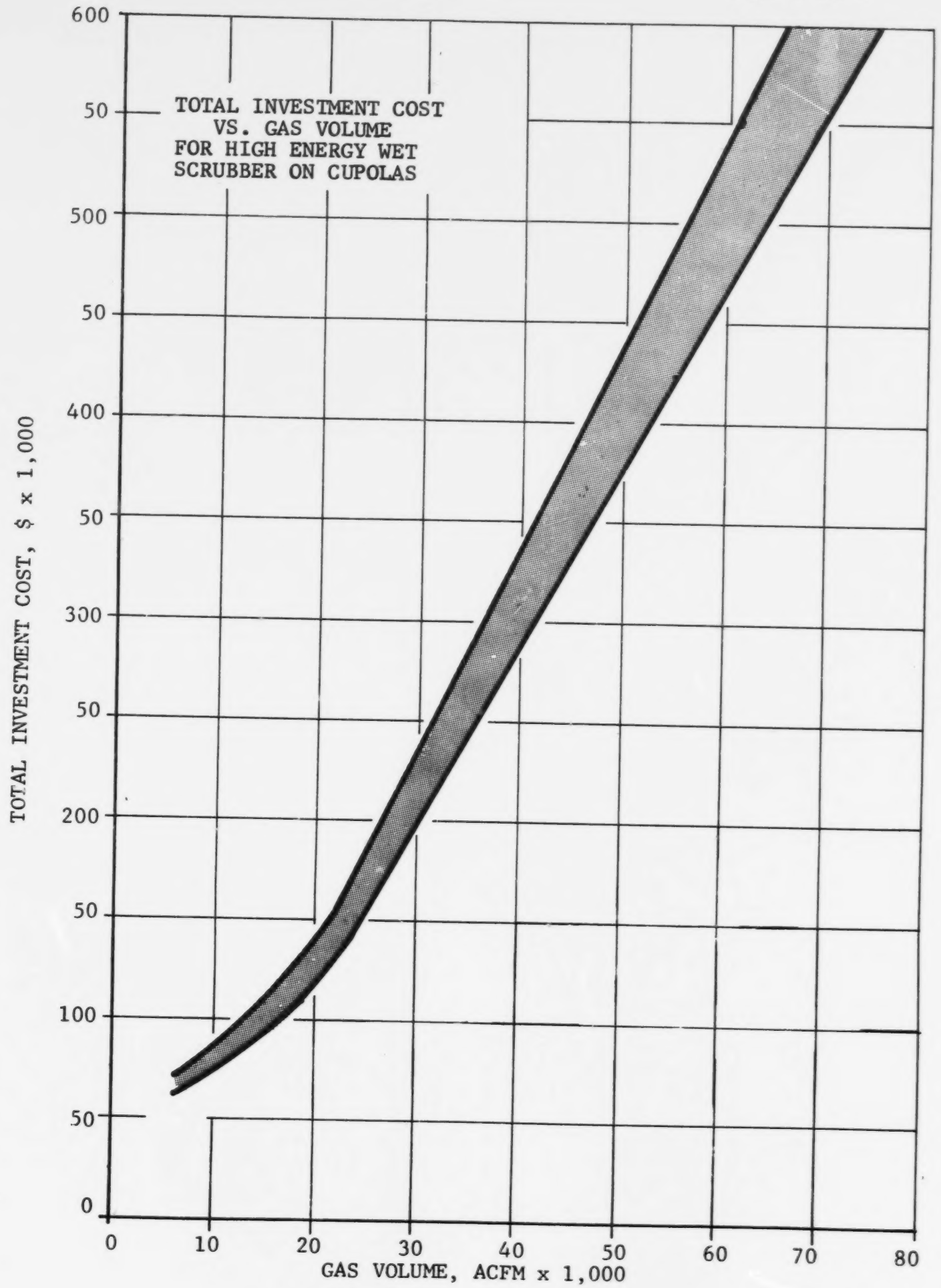
CONDITIONS AFFECTING INSTALLATION COST OF CONTROL DEVICES

<u>Cost Category</u>	<u>Low Cost</u>	<u>High Cost</u>
Utilities	Electricity, water waste disposal facilities readily available.	Electrical and waste treatment facilities must be expanded, water supply must be developed or expanded
Collected waste material handling	No special treatment facilities or handling required	Special treatment facilities and/or handling required
Labor	Low wages in geographical area	Overtime and/or high wages in geographical area

Source: U. S. Department of Health, Education, and Welfare, National Air Pollution Control Administration, Control Techniques for Particulate Air Pollutants, Washington, D. C., 1969.

INVESTMENT COST EQUATIONS FOR
EQUIPMENT INSTALLED ON CUPOLAS

EQUIPMENT TYPE	INVESTMENT COST EQUATION	LIMITS OF OBSERVATION	CORREL. COEF.	REGRESSION PARAMETERS		DATA POINTS
				F RATIO	STD. ERROR	
High Energy Wet Scrubber	I= $49,519 + 2.84 \times \text{Gas Vol.}$ I= $-43,519 + 8.97 \times \text{Gas Vol.}$	$6,000 \leq \text{Gas Vol.} \leq 20,000$ $20,000 \leq \text{Gas Vol.} \leq 92,000$	.82 .99	25 139	16,000 29,000	25
Low Energy Wet Scrubber	I= $38,744 + 2.05 \times \text{Gas Vol.}$	$4,500 \leq \text{Gas Vol.} \leq 67,000$	.84	55	22,000	34
Fabric Filter	I= $-55,000 + 8.95 \times \text{Gas Vol.}$	$10,800 \leq \text{Gas Vol.} \leq 100,000$	.98	321	48,000	19
Mechanical Collector	I= $20,192 + 4.07 \times \text{Gas Vol.}$	$24,000 \leq \text{Gas Vol.} \leq 104,000$	.87	16	70,000	15



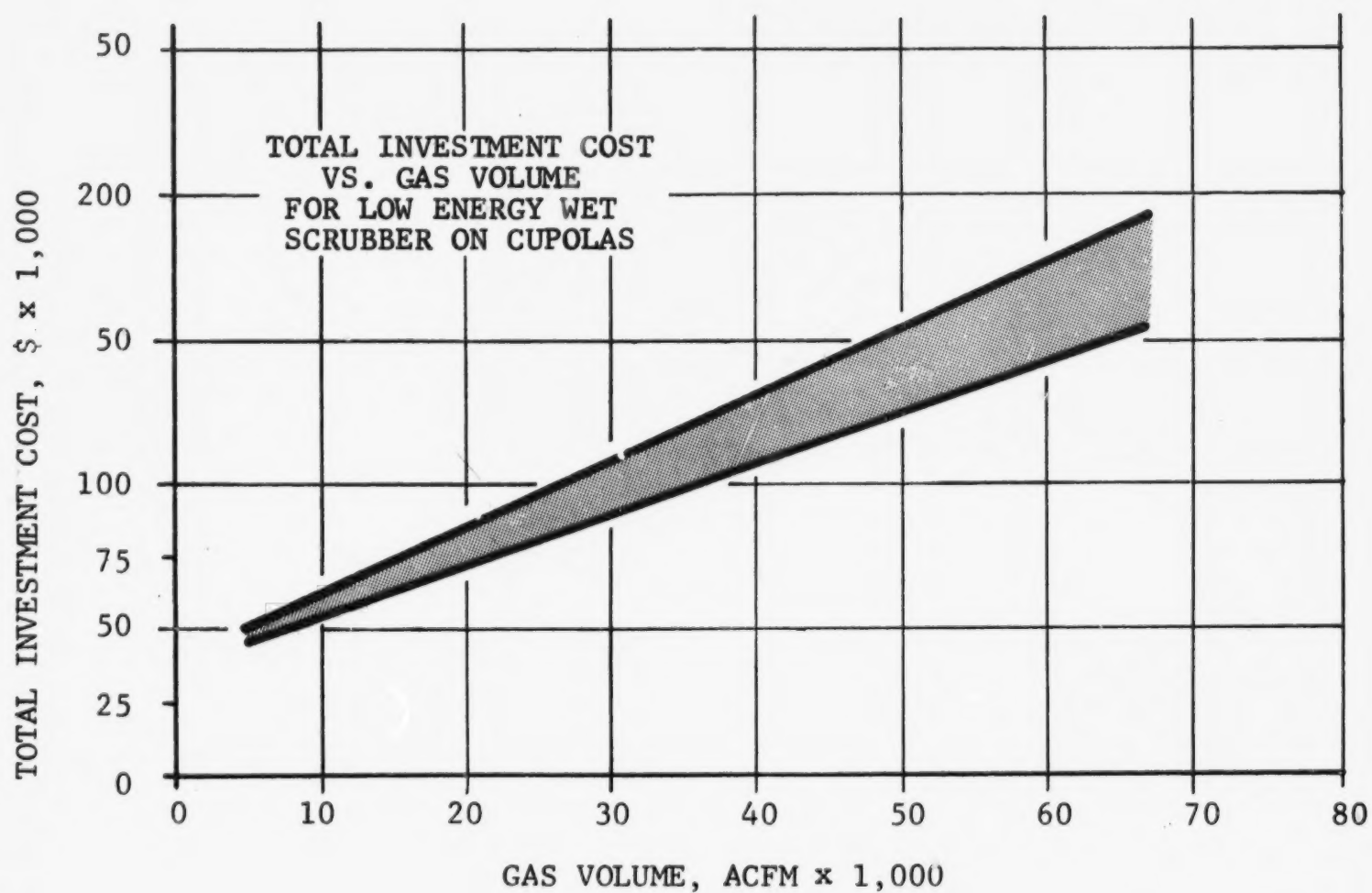
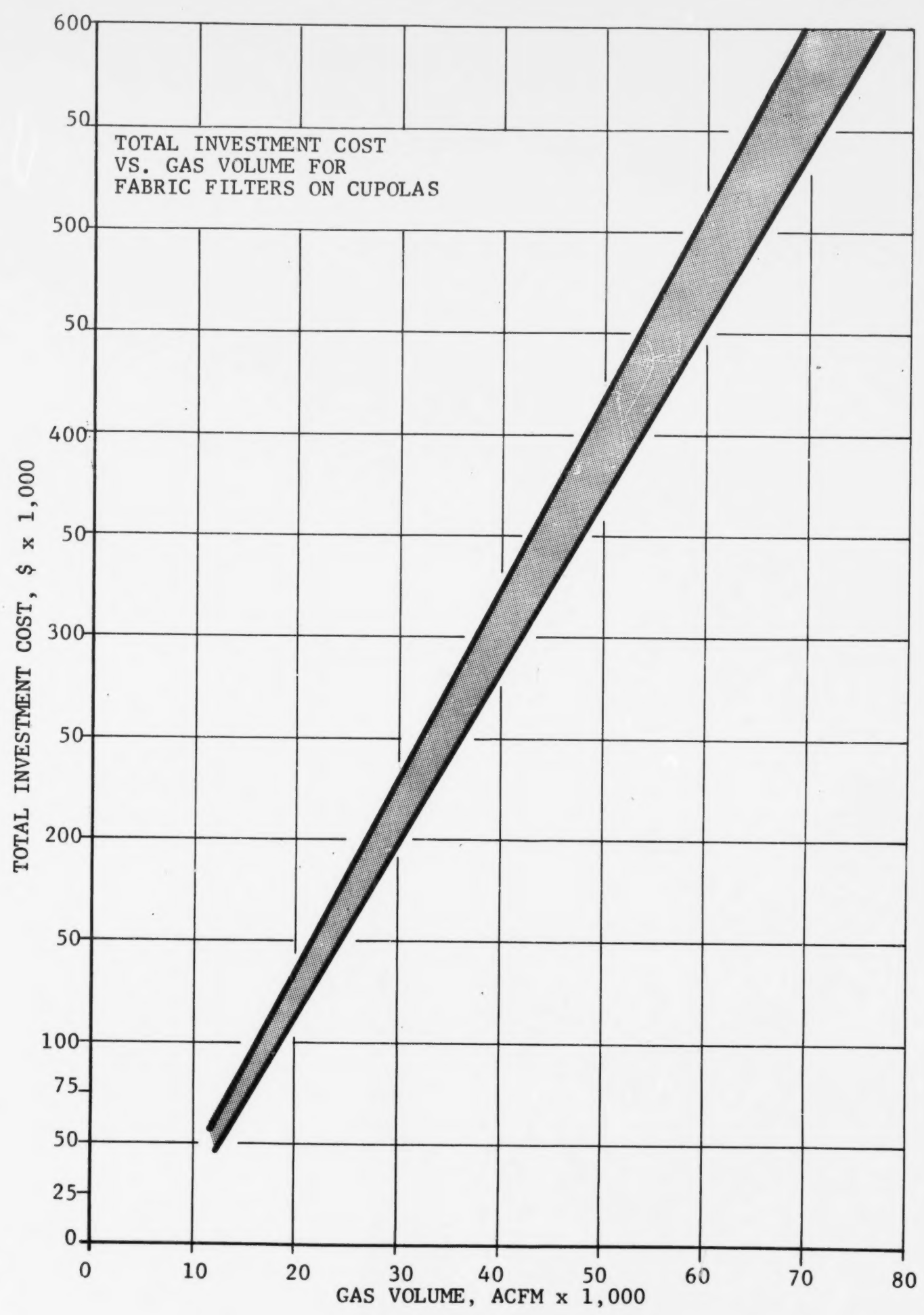
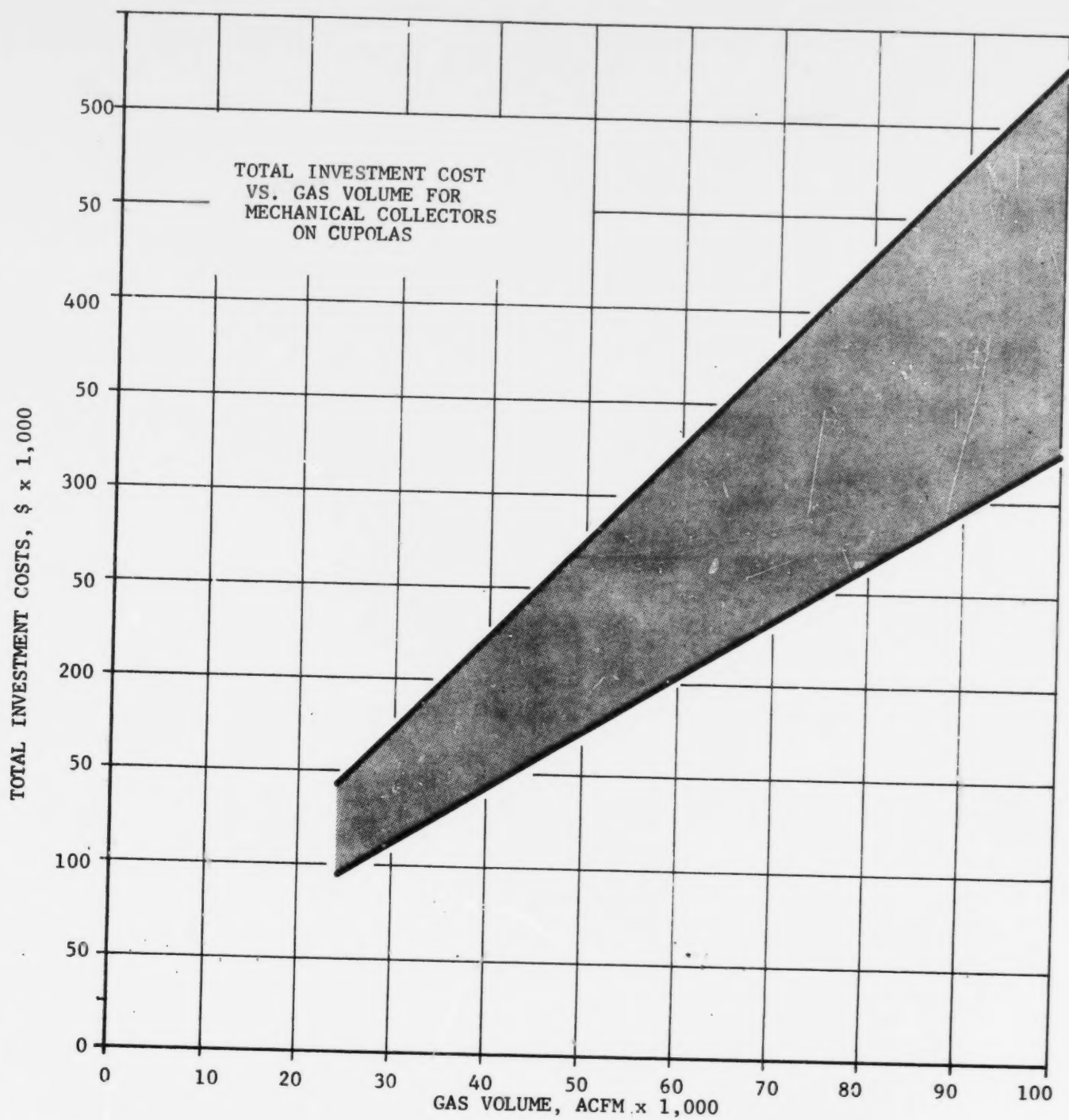


EXHIBIT VIII-4





APPROXIMATE MELTING RATES
FOR LINED CUPS

FCE Lined Dia.	Melt Rate TPH Metal to Coke Ratio				Blast Air (SCFM)	Av. Chg. Door (Sq. Ft.)	Indraft (CFM)
	6/1	8/1	10/1	12/1			
18	3/4	1	-	-	570		
23	1	1-1/2	-	-	940	10	3,000
27	1-3/4	2-1/4	-	-	1,290	10	3,000
32	2-1/2	3-1/4	4	-	1,810	10	3,000
37	3-1/4	4-1/4	5-1/4	-	2,420	11-1/4	3,380
42	4	5-1/2	7	-	3,100	16-1/2	4,950
45	4-1/2	6-1/4	8	-	3,600	22	6,600
48	5-1/2	7-1/4	9	10-3/4	4,100	45	13,500
54	7	9-1/4	11-1/2	13-3/4	5,200	50	15,000
60	9	11-1/4	14	17	6,400	50	15,000
66	10-1/2	13-3/4	17	20-1/2	7,700	52	15,600
72	12-1/4	16-1/4	20-1/4	24-1/2	9,200	52	15,600
78	15	19	23-3/4	28-3/4	10,700	60	18,000
84	17	22-1/4	27-3/4	33-1/4	12,500	63	18,900

Adapted from Useful Information for Foundrymen published by Whiting Corporation.

Assumptions:

1. No door closure
2. No oxygen enrichment
3. No fuel injection
4. Indraft at 300 FPM

A

OXIMATE MELTING RATES AND GAS VOLUMES
FOR LINED CUPOLAS

Av. Chg. Door (Sq. Ft.)	Indraft (CFM)	Above- Door Total (SCFM)	Below- Door Total (SCFM)	Above Door (ACFM)	Below Door @1850° F (ACFM)
			650		2,000
10	3,000	3,940	1,050	7,700	3,000
10	3,000	4,290	1,450	8,500	4,000
10	3,000	4,810	2,000	10,800	5,000
11-1/4	3,380	5,800	2,700	13,100	7,000
16-1/2	4,950	3,050	3,500	18,100	9,000
22	6,600	10,200	4,000	23,000	12,000
45	13,500	17,600	4,600	34,500	16,000
50	15,000	20,200	5,800	39,500	18,000
50	15,000	21,400	7,100	42,500	20,000
52	15,600	23,300	8,500	51,000	23,000
52	15,600	24,800	10,500	56,000	28,000
60	18,000	28,700	12,000	65,000	32,000
63	18,900	31,400	14,000	71,000	37,000

by Whiting Corporation.

B

APPROXIMATE MELTING RATES AND
GAS VOLUMES FOR UNLINED CUPOLAS

FCE Dia.	Melt Rate TPH						Blast Air (SCFM)	Av. Chg. Door (Sq. Ft.)	Indra (CFM)
	Metal to Coke Ratio (1000° F Hot Blast)								
	5/1	6/1	7/1	8/1	9/1	10/1			
36	4-1/2	4-3/4	5	5-1/2	5-3/4	6-1/4	2,300	12	3,600
42	6-1/4	6-1/2	6-3/4	7-1/4	7-3/4	8-1/4	3,100	16-1/2	4,900
48	8	8-1/4	9	9-3/4	10-1/2	11-1/4	4,100	45	13,500
54	10	10-1/2	11-1/2	12-1/4	13-1/4	14-1/4	5,200	50	15,000
60	12-1/2	13	13-1/2	15-1/4	16-1/4	17-1/4	6,400	50	15,000
66	15	15-1/2	17	18-1/4	19-3/4	20-3/4	7,700	52	15,600
72	17-3/4	18-1/2	20	22	23-1/4	25	9,200	60	18,000
78	20-3/4	21-3/4	23-1/4	25-1/2	27-1/4	29	10,700	60	18,000
84	24-1/4	25-1/4	27-1/4	29-1/4	32	34	12,500	63	18,900
90	27-3/4	29	31-1/2	34-1/4	36-1/4	39	14,300	95	28,500
96	31-3/4	33	34-1/2	39	41-1/2	44	16,300	110	33,000
102	36	37-1/4	40-1/2	44	47	50	18,400	120	36,000
108	40	41-1/2	45	49	52-1/2	56	20,600	128	38,400

Adapted from Useful Information for Foundrymen published by Whiting Corporation.

Assumptions:

1. No door closure
2. No oxygen enrichment
3. No fuel injection
4. Indraft at 300 FPM

A

TE MELTING RATES AND
FOR UNLINED CUPOLAS

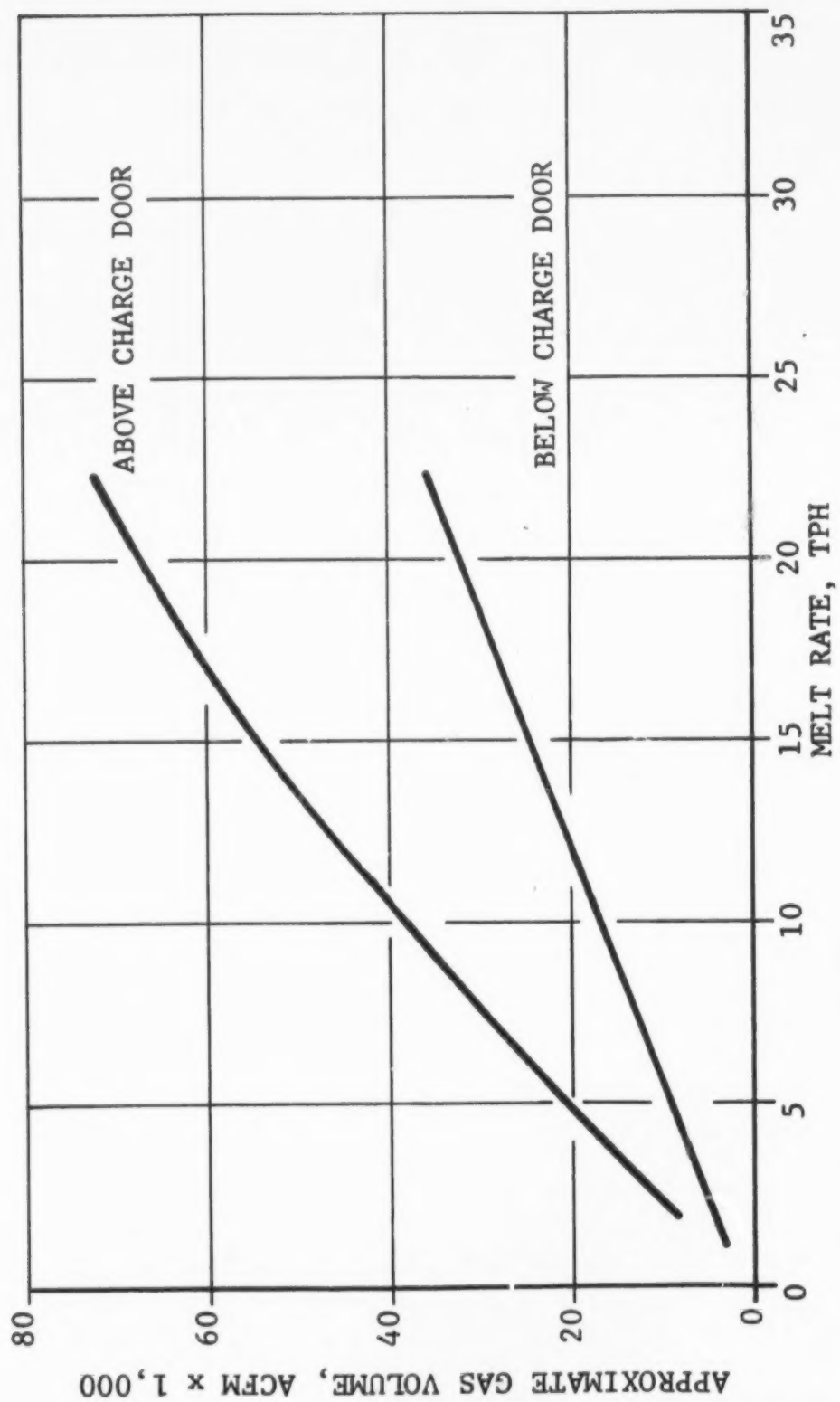
EXHIBIT VIII-7

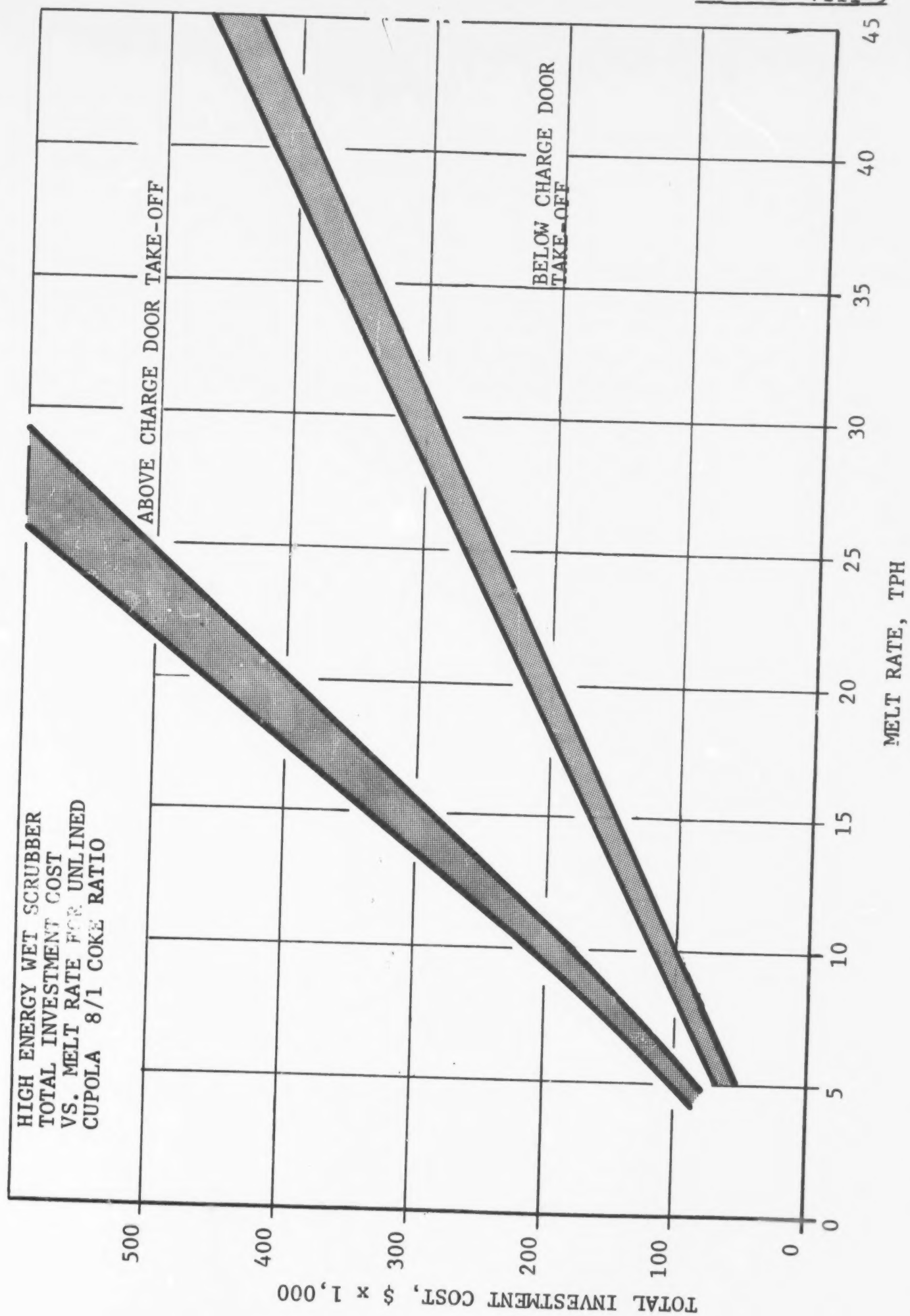
ast r (CFM)	Av. Chg. Door (Sq. Ft.)	Indraft (CFM)	Above- Door Total (SCFM)	Below- Door Total (SCFM)	Above Door (ACFM)	Below Door @ 850° F (ACFM)
800	12	3,600	5,900	2,600	13,300	7,000
1000	16-1/2	4,950	8,050	3,500	18,100	9,000
1000	45	13,500	17,600	4,600	34,500	16,000
2000	50	15,000	20,200	5,800	39,500	18,000
4000	50	15,000	21,400	7,100	41,500	20,000
7000	52	15,600	23,300	8,500	51,000	23,000
2000	60	18,000	27,200	10,500	59,200	28,000
7000	60	18,000	28,700	12,000	65,000	32,000
8000	63	18,900	31,400	14,000	71,000	35,000
8000	95	28,500	42,800	16,000	93,000	42,000
8000	110	33,000	49,300	18,000	105,000	48,000
4000	120	36,000	54,400	21,000	115,000	56,000
6000	128	38,400	59,000	23,000	128,000	62,000

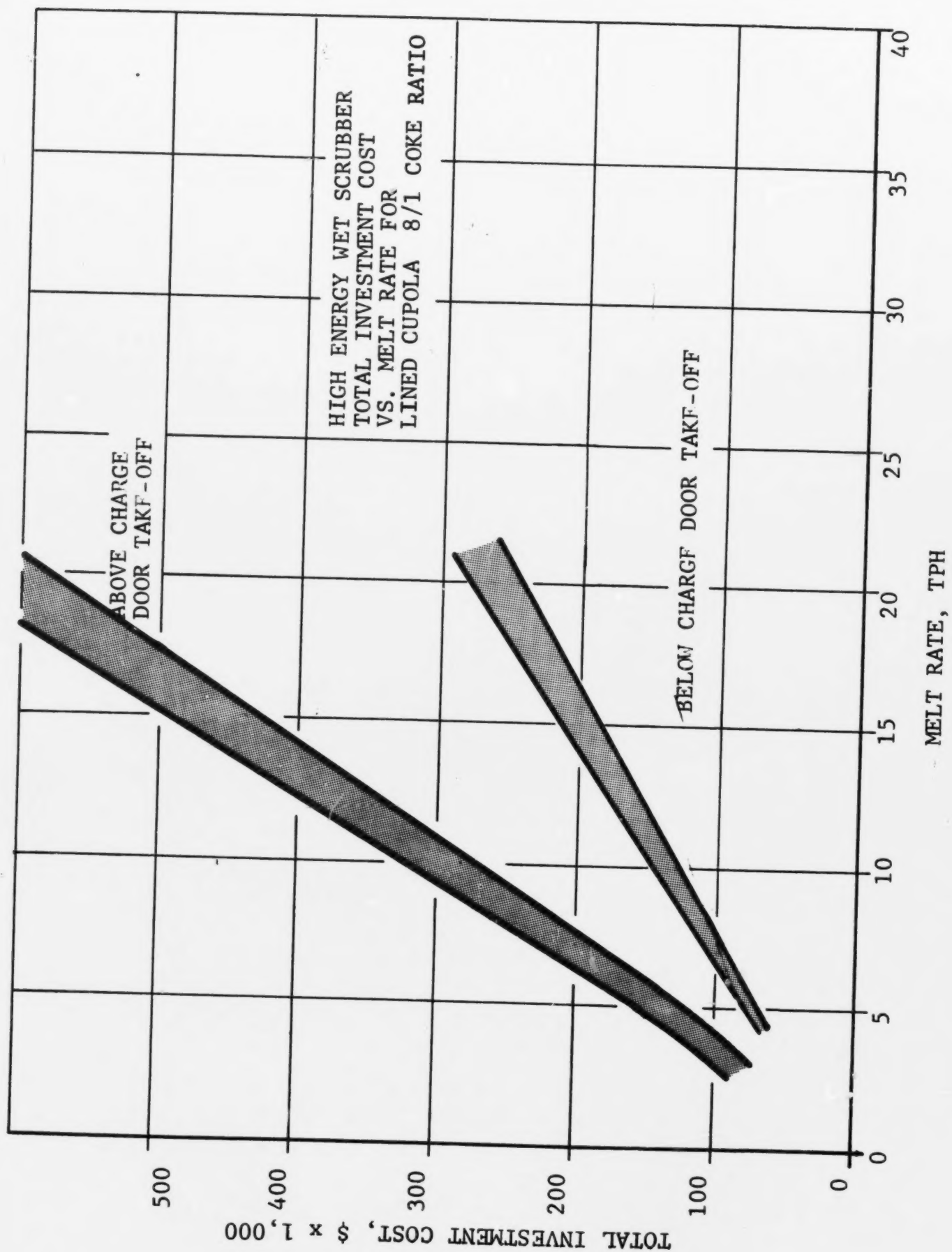
ng Corporation.

B

COMPARISON OF GAS TAKE-OFF
ABOVE CHARGE DOOR AND BELOW
CHARGE DOOR, LINED CUPOLA
COKE RATIO 8/1

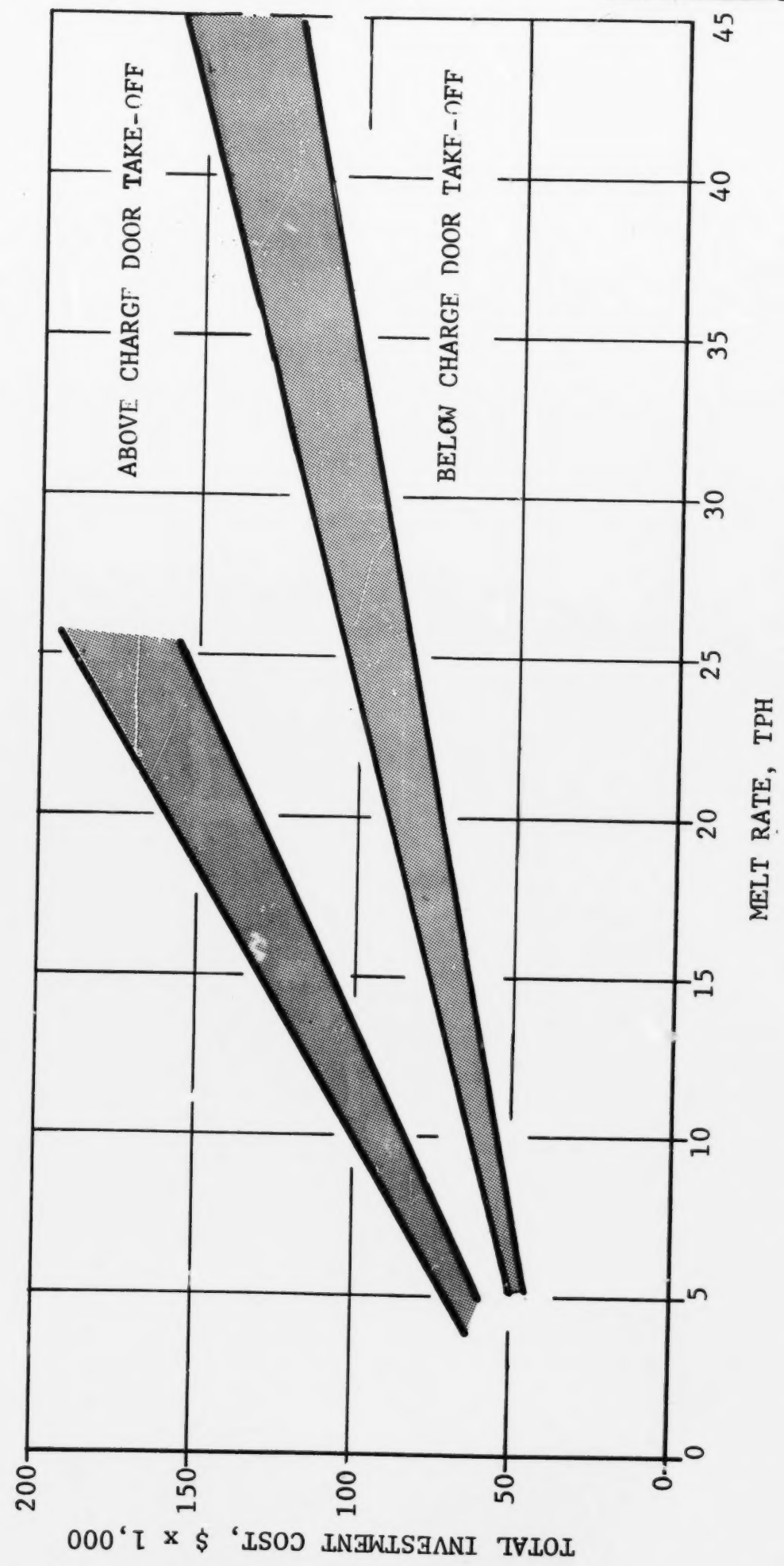






LOW ENERGY WET SCRUBBER
 TOTAL INVESTMENT COST
 VS. MELT RATE FOR UNLINED
 CUPOLA 8/1 COKE RATIO

EXHIBIT VIII-11



LOW ENERGY WET SCRUBBER
TOTAL INVESTMENT COST
VS. MELT RATE FOR LINED
CUPOLA 8/1 COKE RATIO

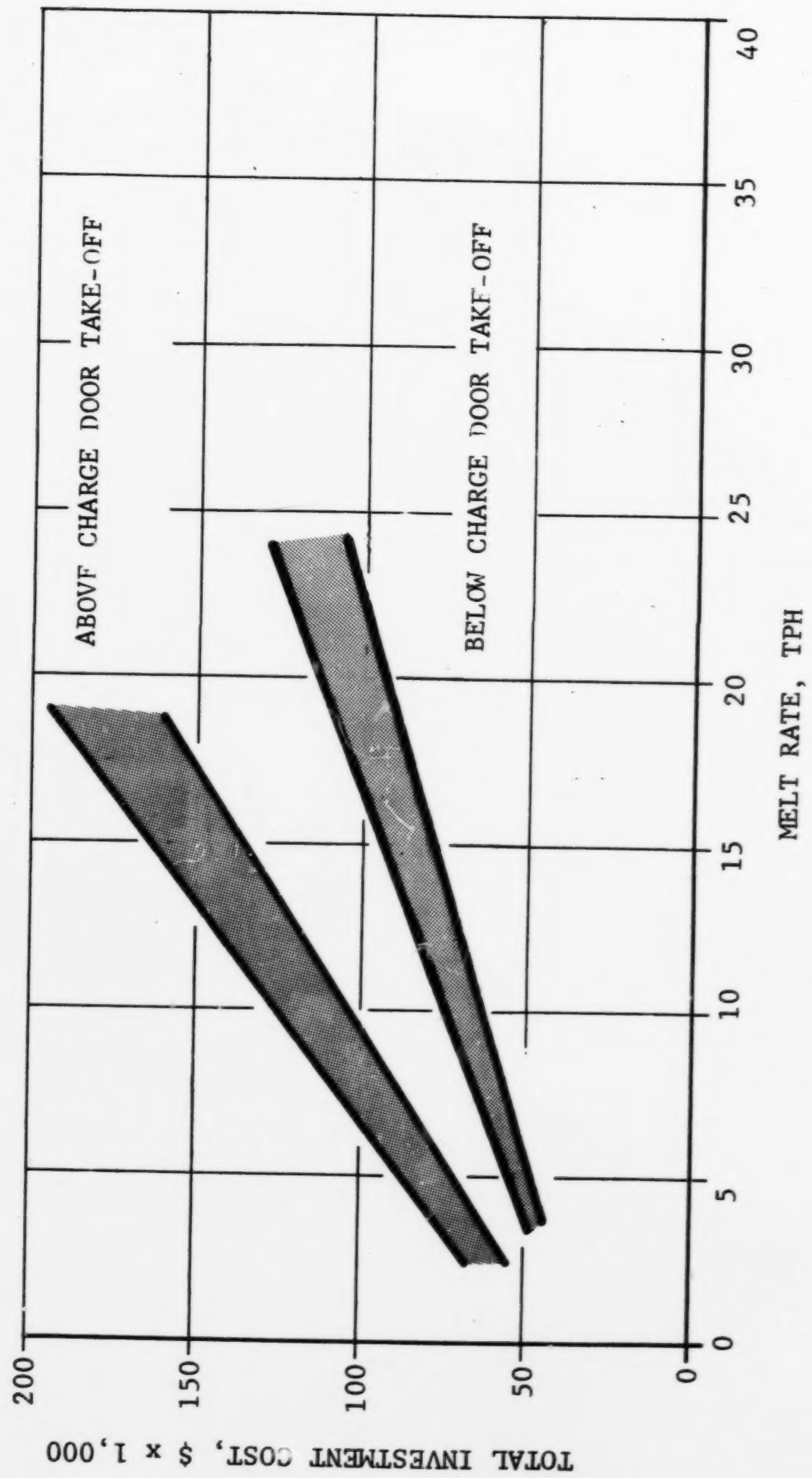
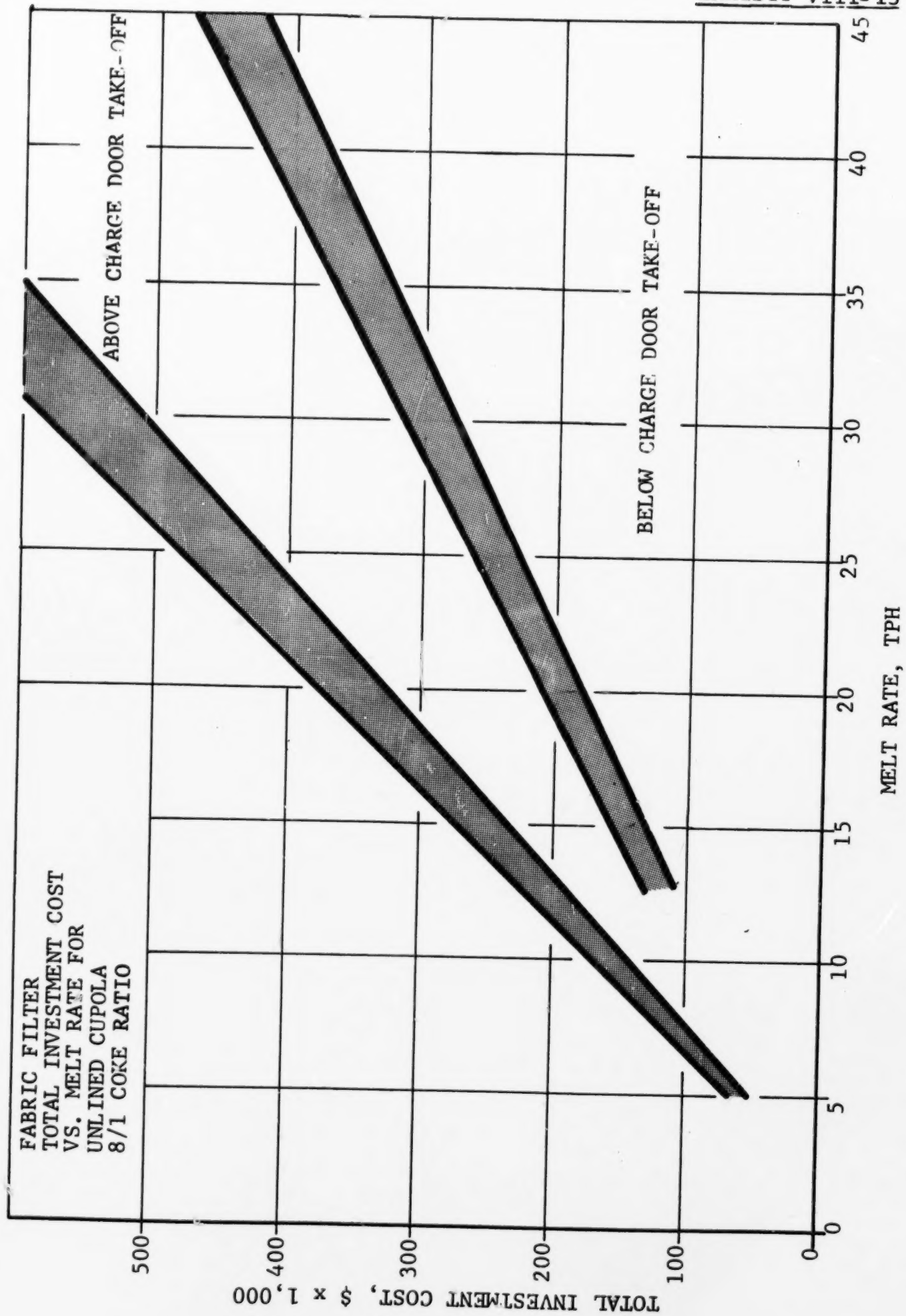
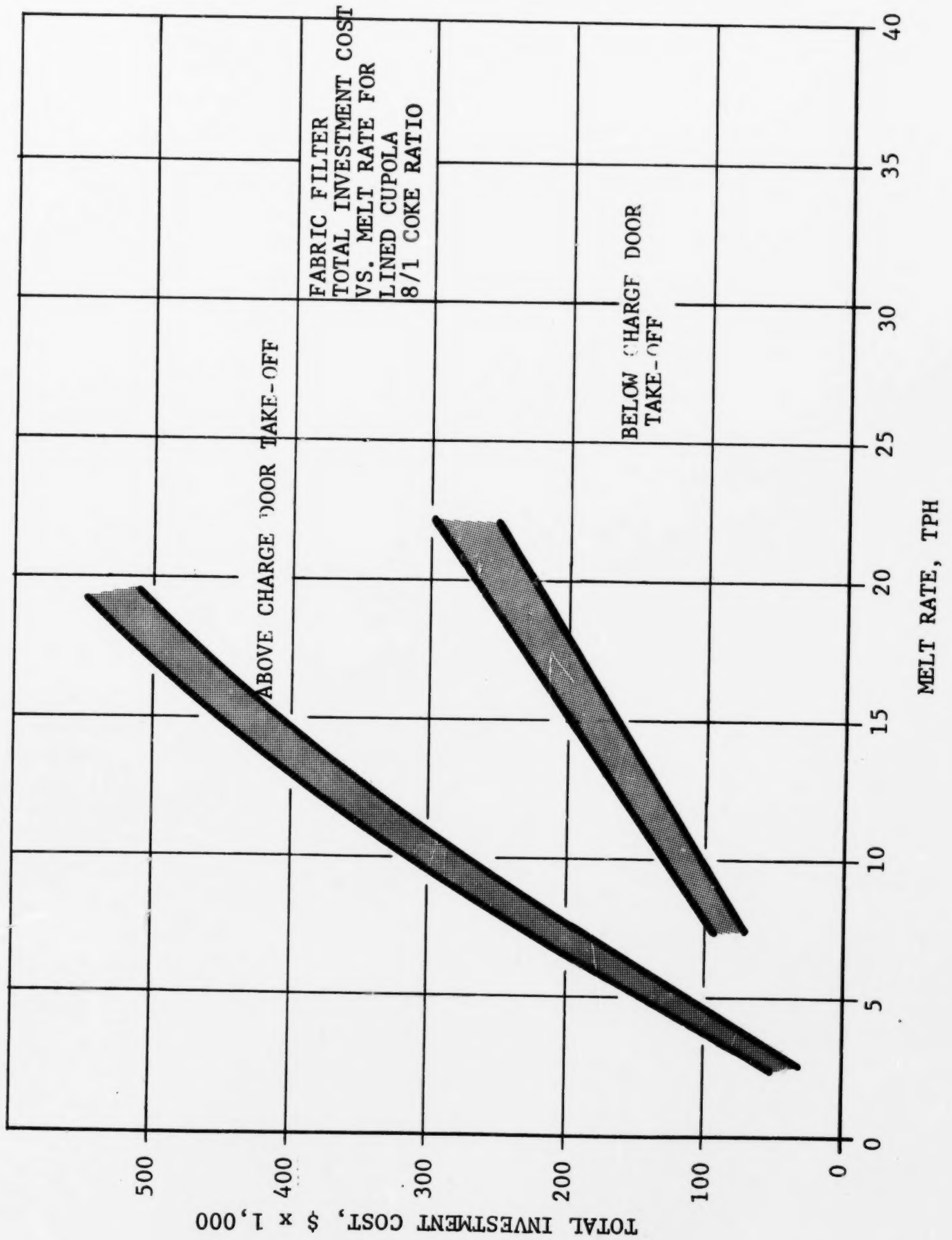
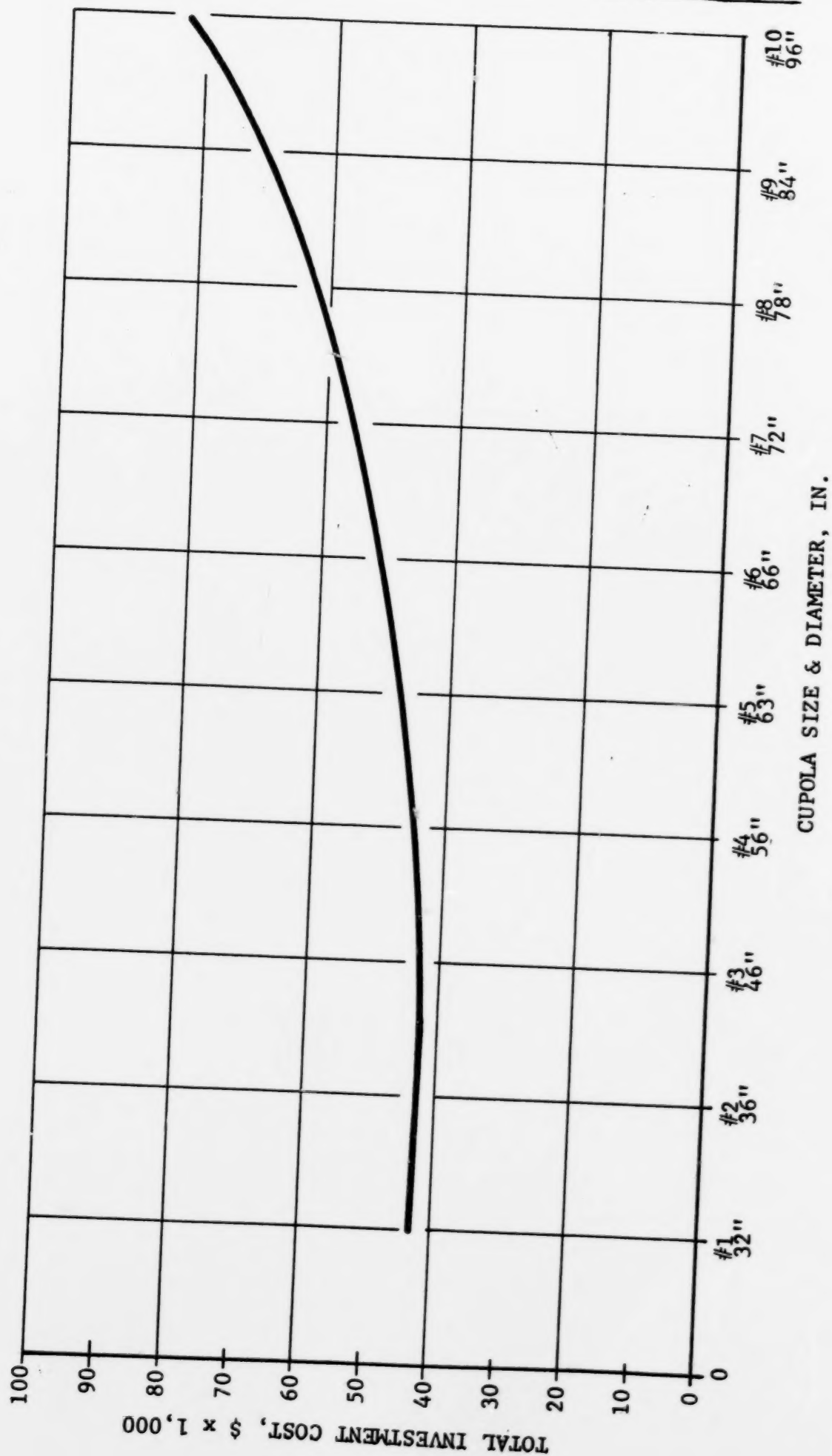


EXHIBIT VIII-13





TOTAL INVESTMENT COSTS
FOR WET CAPS



**CALCULATION OF WET SCRUBBER EFFICIENCY
FOR VARIOUS PRESSURE DROPS**

Size of Particles, Microns	Percent of Particles(1)		Efficiency at Mean Size of Particles, Percent(2)								Overall Collection Efficiency, Percent											
											Cold Blast						Hot Blast					
	Cold Blast	Hot Blast	5"	10"	20"	30"	40"	60"	5"	10"	20"	30"	40"	60"	5"	10"	20"	30"	40"	60"		
Over 200	15%	5%	100%	100%	100%	100%	100%	100%	15%	15%	15%	15%	15%	15%	5%	5%	5%	5%	5%	5%		
100-200	10	15	100	100	100	100	100	100	10	10	10	10	10	10	15	15	15	15	15	15		
50-100	15	20	99.9	100	100	100	100	100	14.9	15	15	15	15	15	19.9	20	20	20	20	20		
20-50	15	20	99.9	99.9	99.9	99.9	100	100	14.9	14.9	14.9	14.9	15	15	19.9	19.9	19.9	19.9	20	20		
10-20	20	5	99.5	99.9	99.9	99.9	99.9	100	19.9	19.9	19.9	19.9	19.9	20	4.9	4.9	4.9	4.9	4.9	5		
5-10	5	5	97.5	99.4	99.9	99.9	99.9	100	4.8	4.9	4.9	4.9	4.9	5	4.8	4.9	4.9	4.9	4.9	5		
2-5	5	10	95	98.5	99.7	99.9	99.9	99.9	4.7	4.9	4.9	4.9	4.9	4.9	9.5	9.8	9.9	9.9	9.9	9.9		
0-2	15	20	82	93	98.3	99.4	99.7	99.9	12.3	13.9	14.7	14.9	14.9	14.9	16.4	18.6	19.6	19.8	19.8	19.9		
Total	100%	100%									96.5%	98.5%	99.3%	99.5%	99.6%	99.8%	95.4%	98.1%	99.2%	99.4%	99.5%	99.8%

Notes: (1) Engela & Weber, "Cupola Emission Control"
(2) From Exhibit VII-28.

COMPARISON OF CUPOLA OUTLET
DUST LOADING AND PRESSURE
DROP FOR WET SCRUBBERS

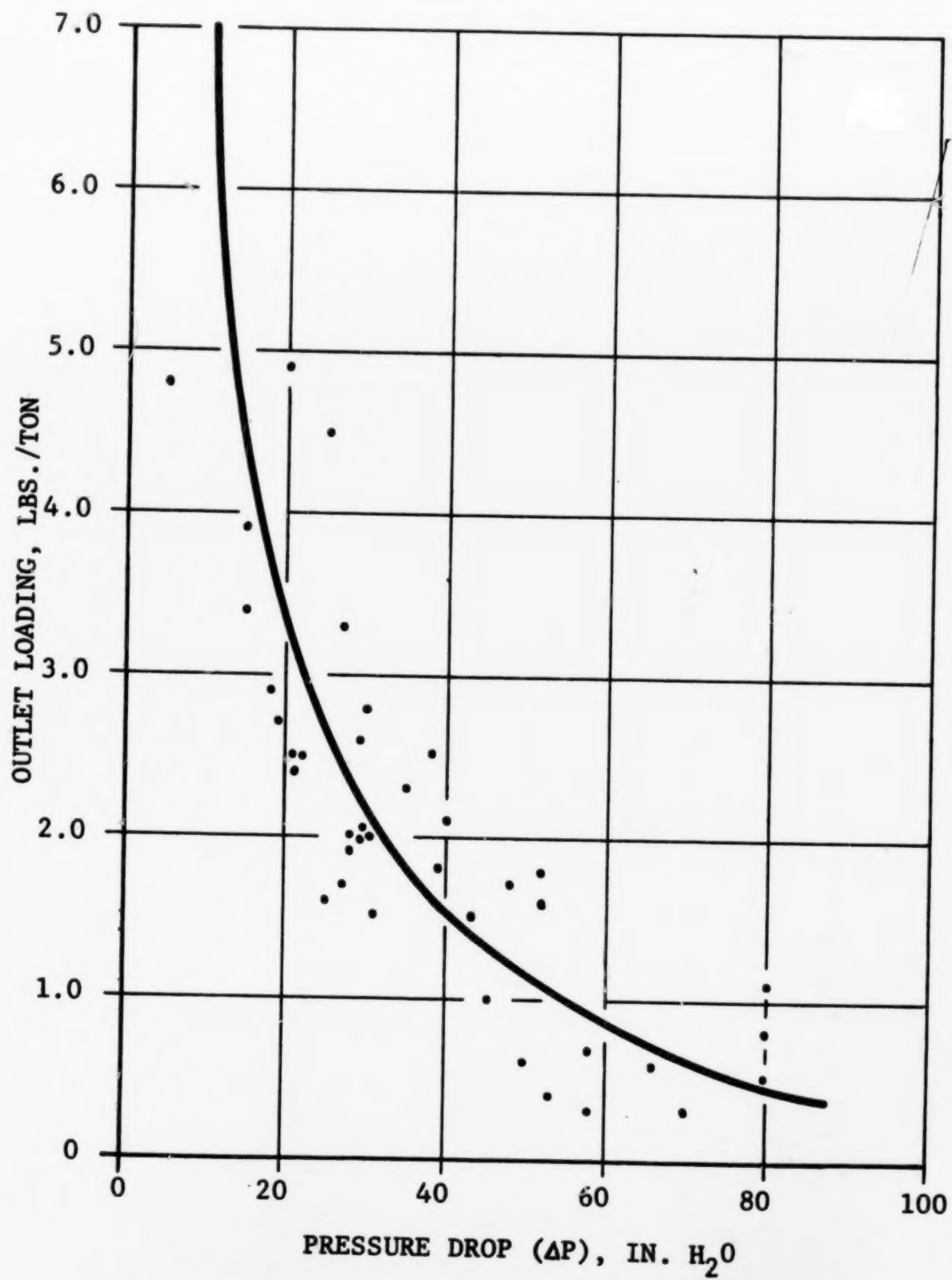
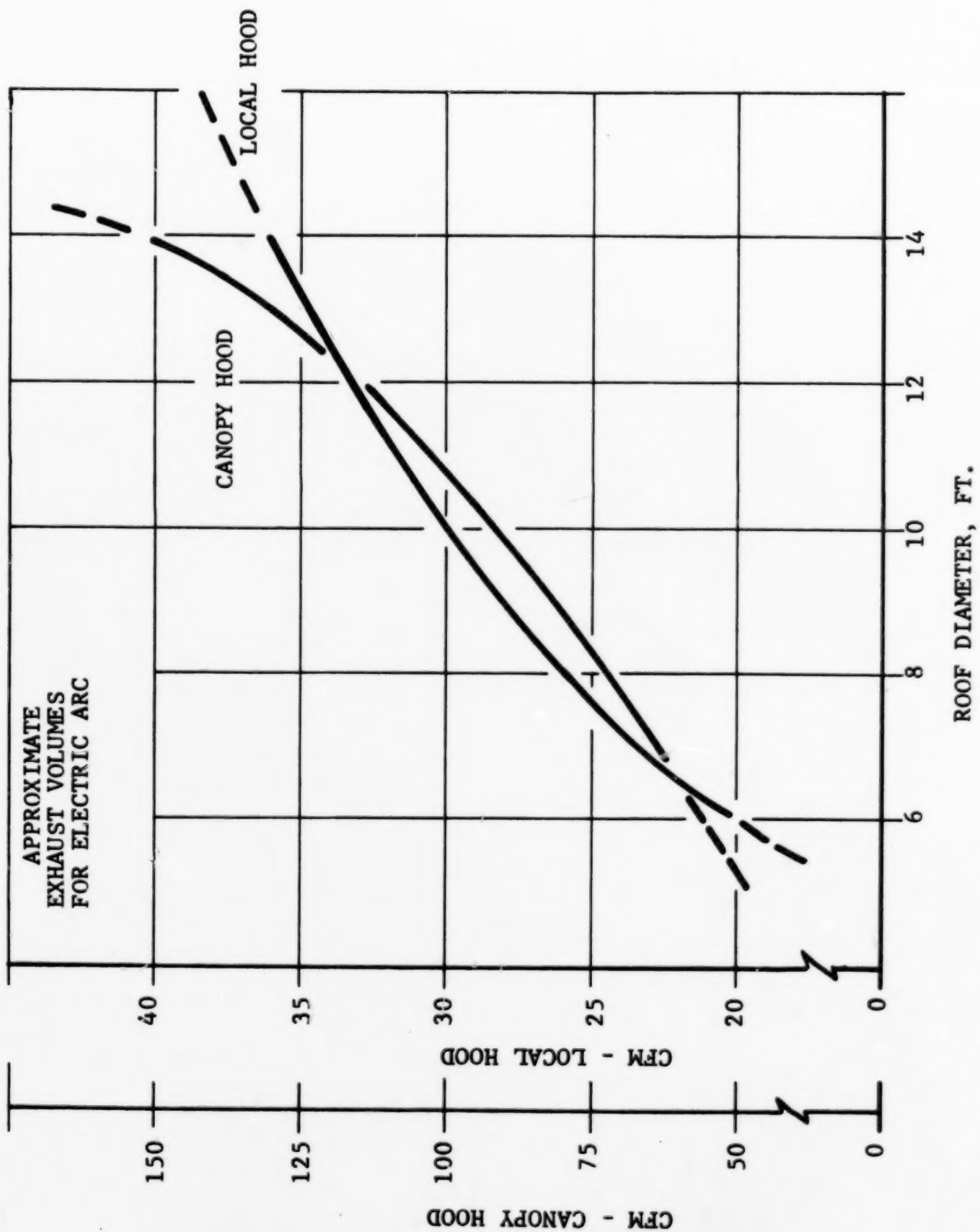
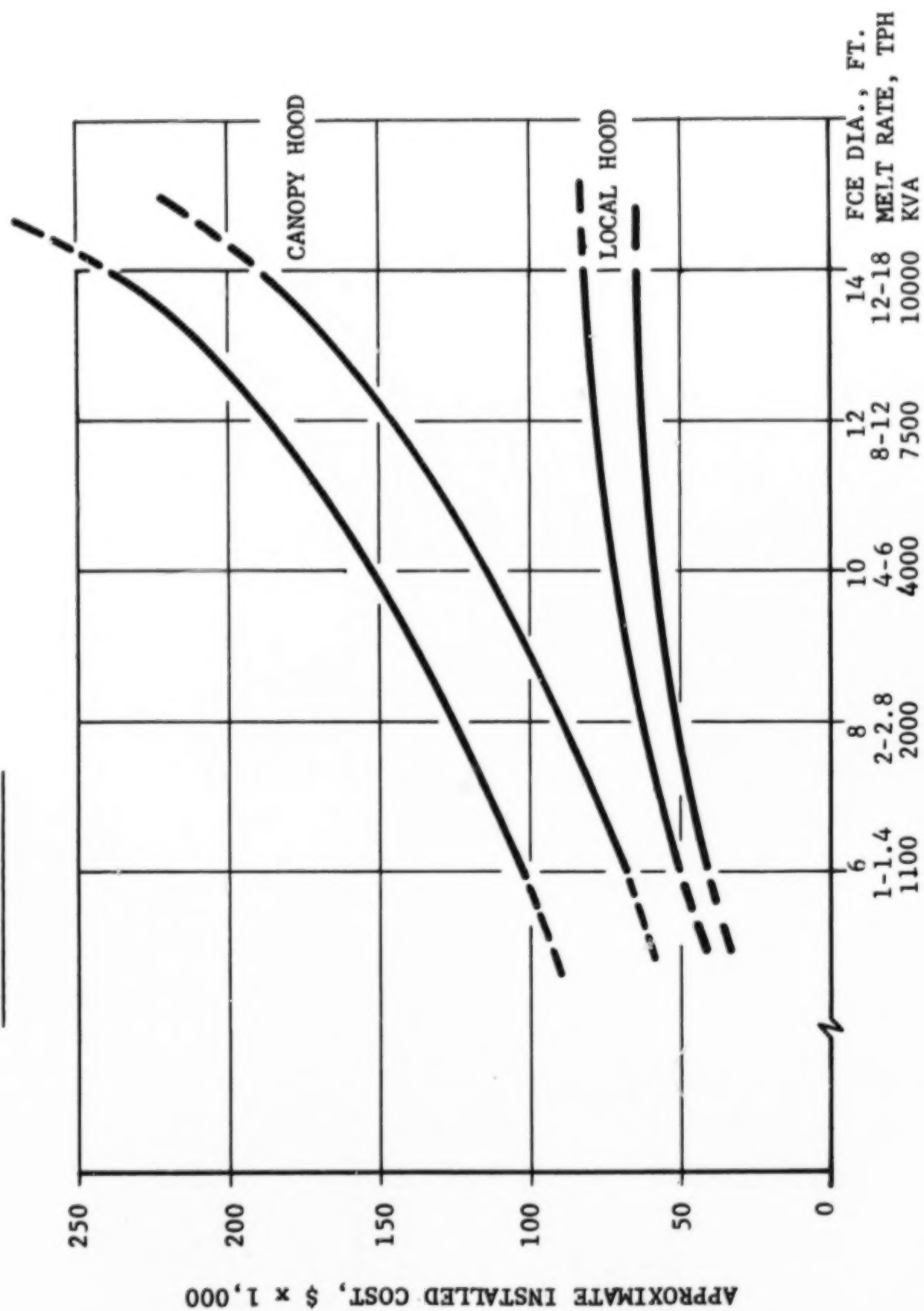


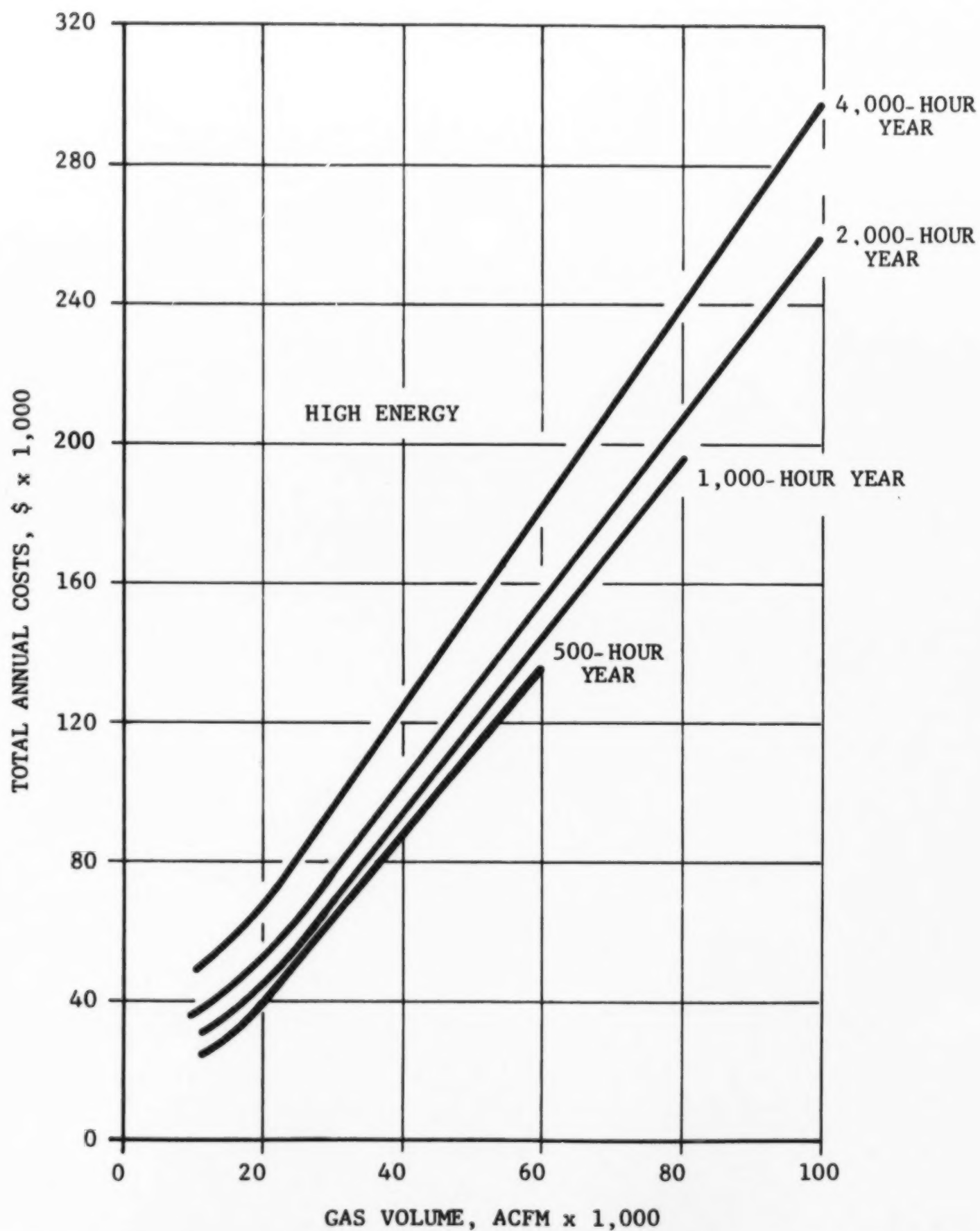
EXHIBIT VIII-18



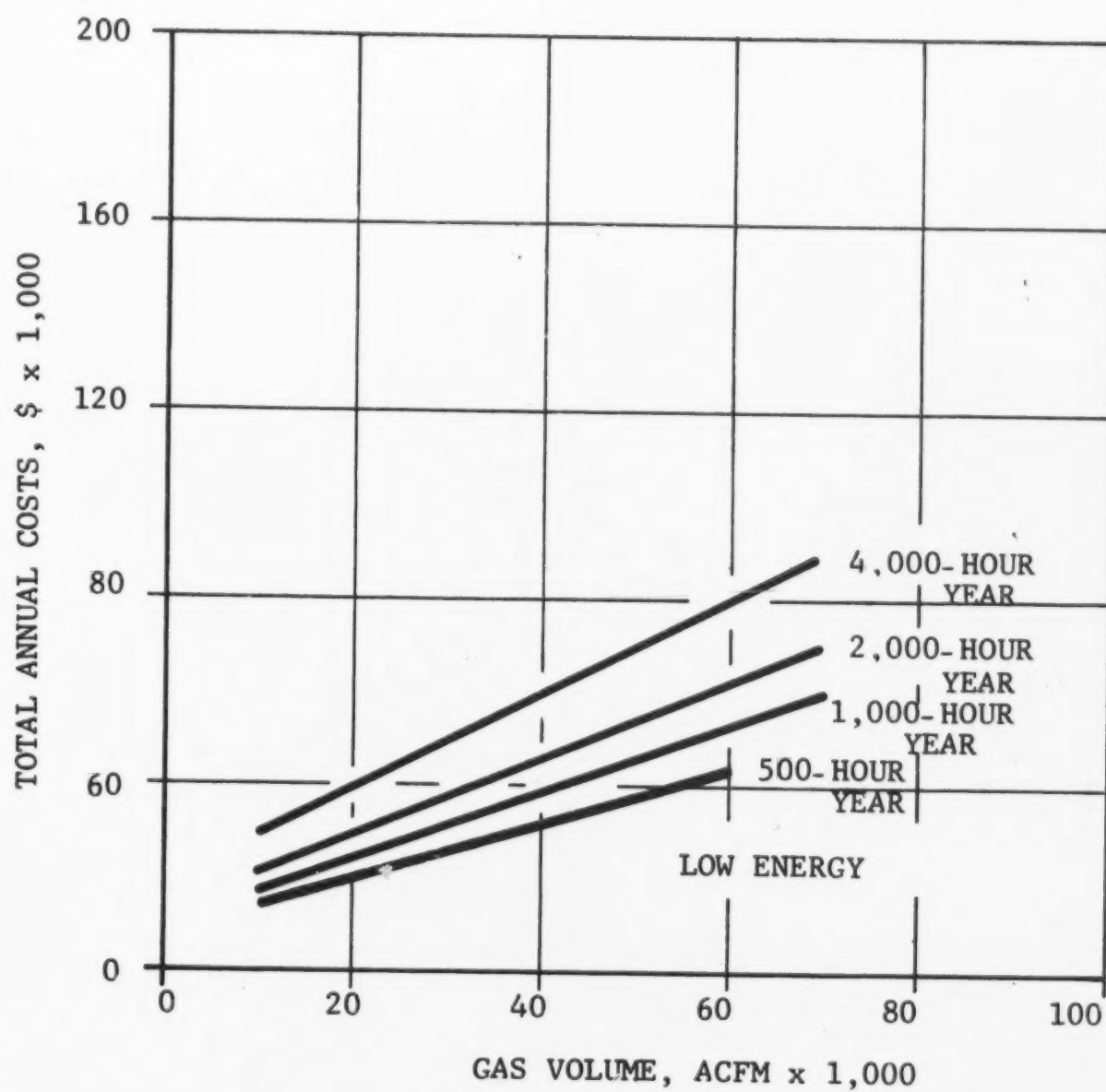
INSTALLED COST OF
FABRIC FILTER ON
ELECTRIC ARC



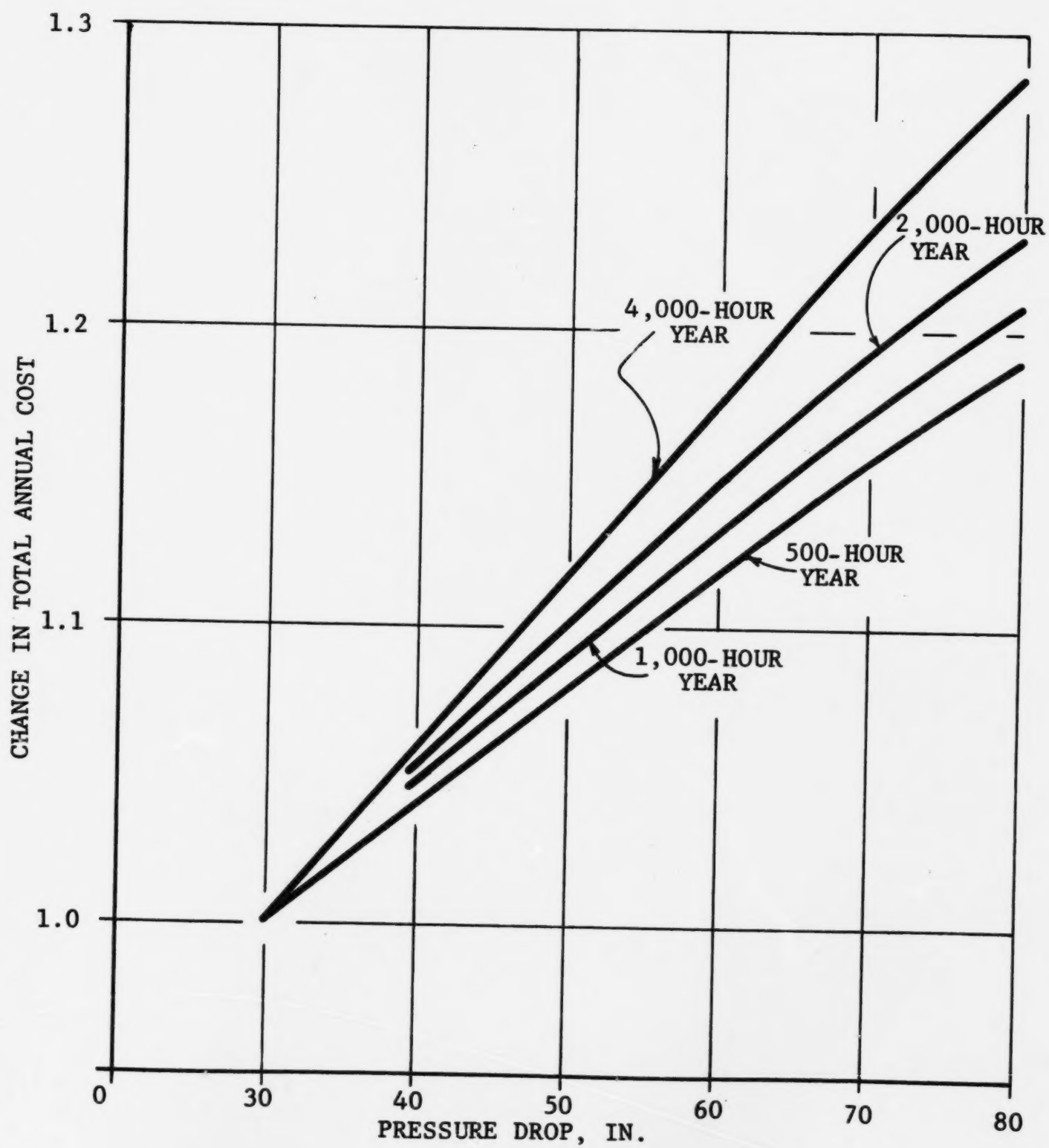
TOTAL ANNUAL COSTS
FOR HIGH
ENERGY WET SCRUBBERS
ON CUPOLAS



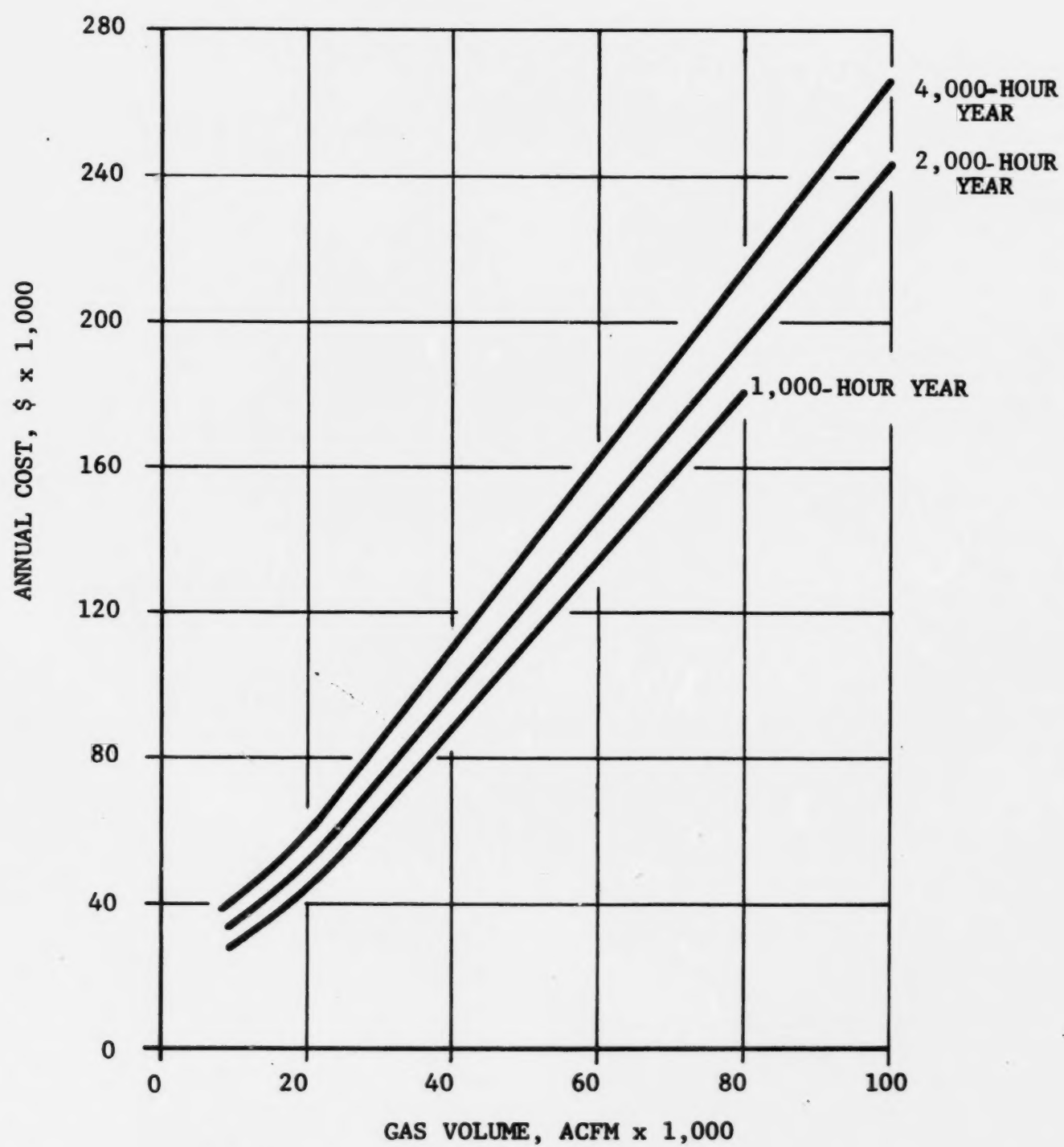
TOTAL ANNUAL COSTS
FOR LOW
ENERGY WET SCRUBBERS
ON CUPOLAS



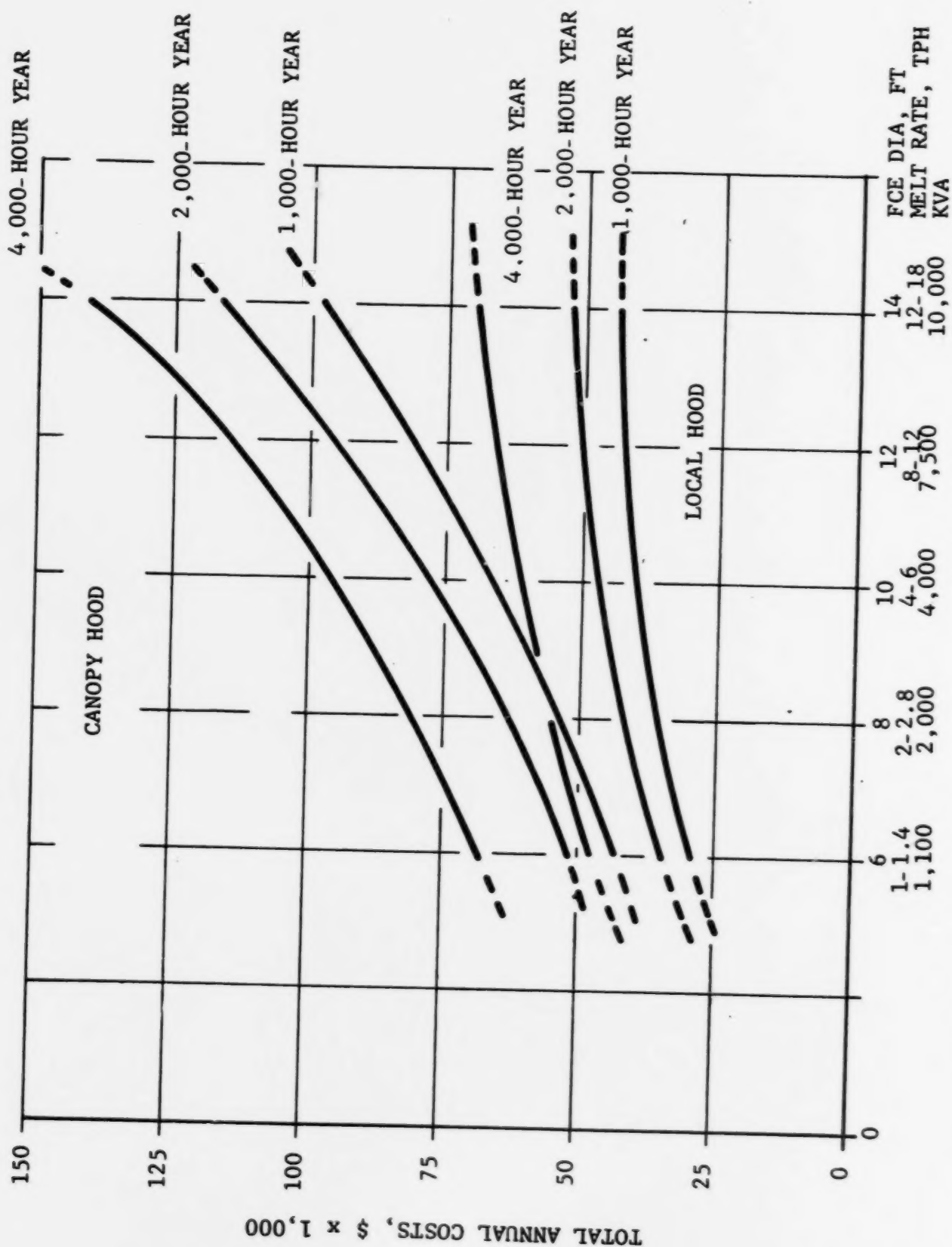
RELATIVE CHANGE IN TOTAL
ANNUAL COSTS VS. PRESSURE
DROP FOR WET SCRUBBERS



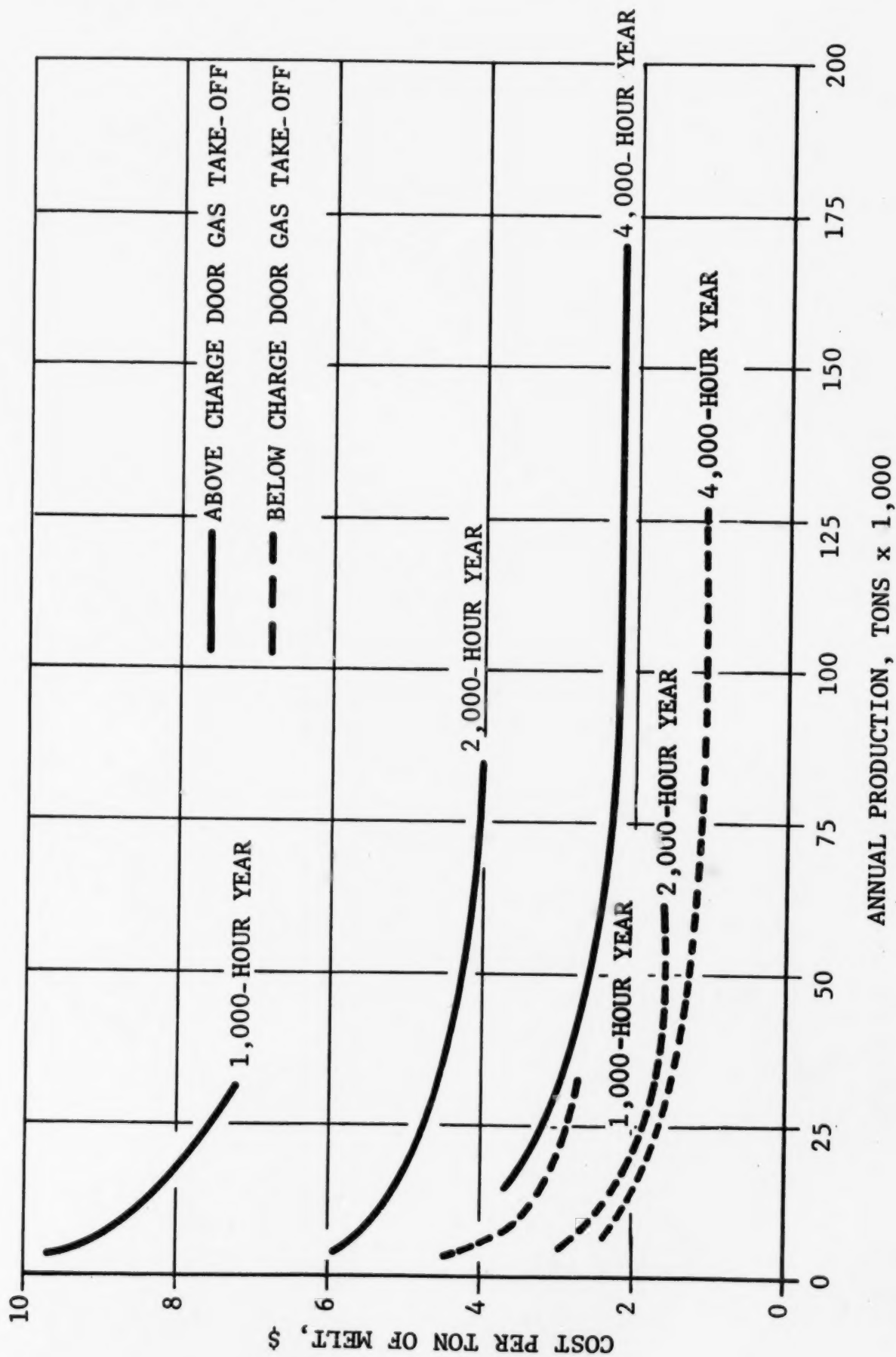
**TOTAL ANNUAL COST FOR
FABRIC FILTERS ON CUPOLAS**
(Air Cooling of Gas)



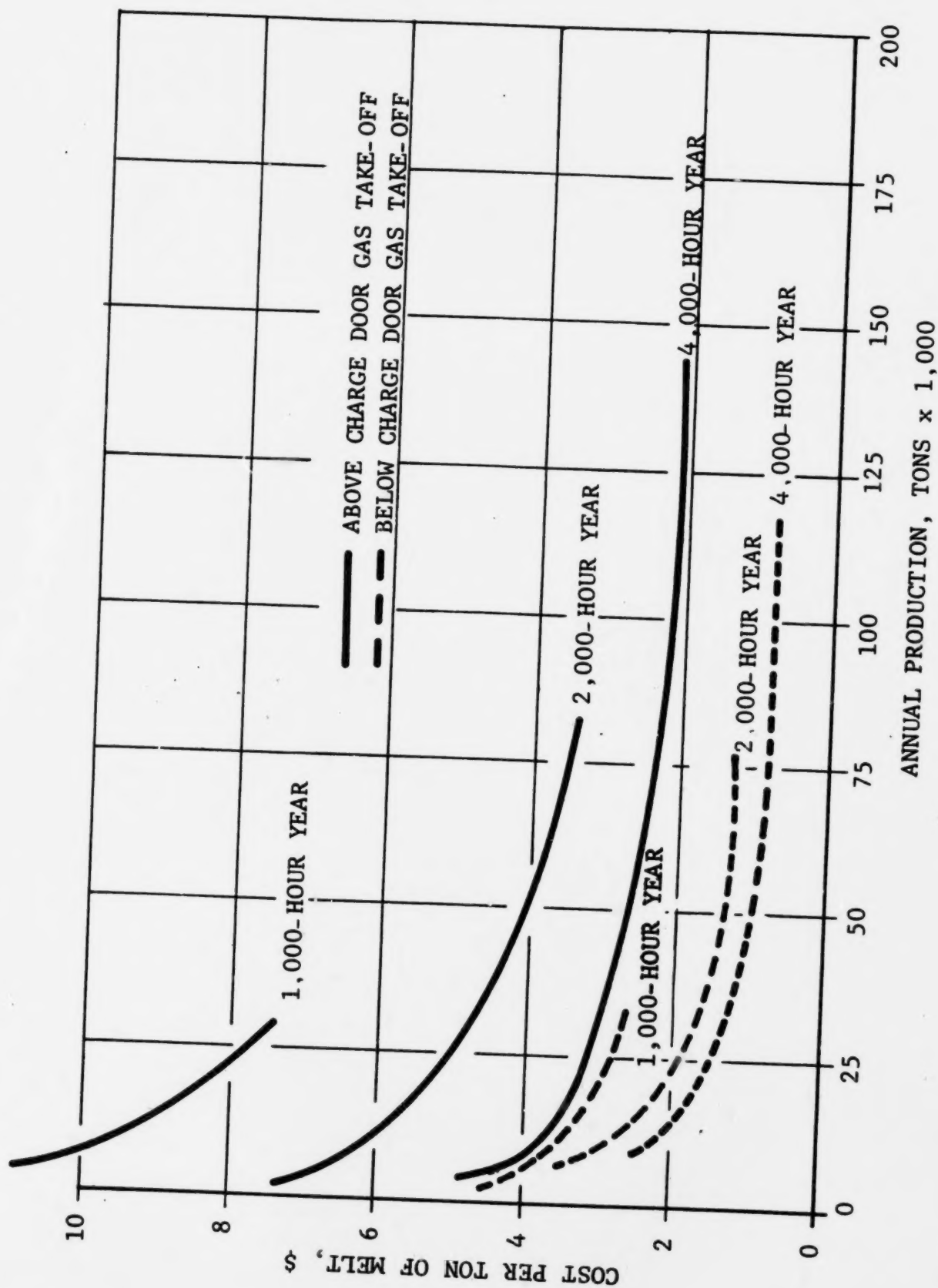
TOTAL ANNUAL COST
FOR FABRIC FILTERS ON
ELECTRIC ARC



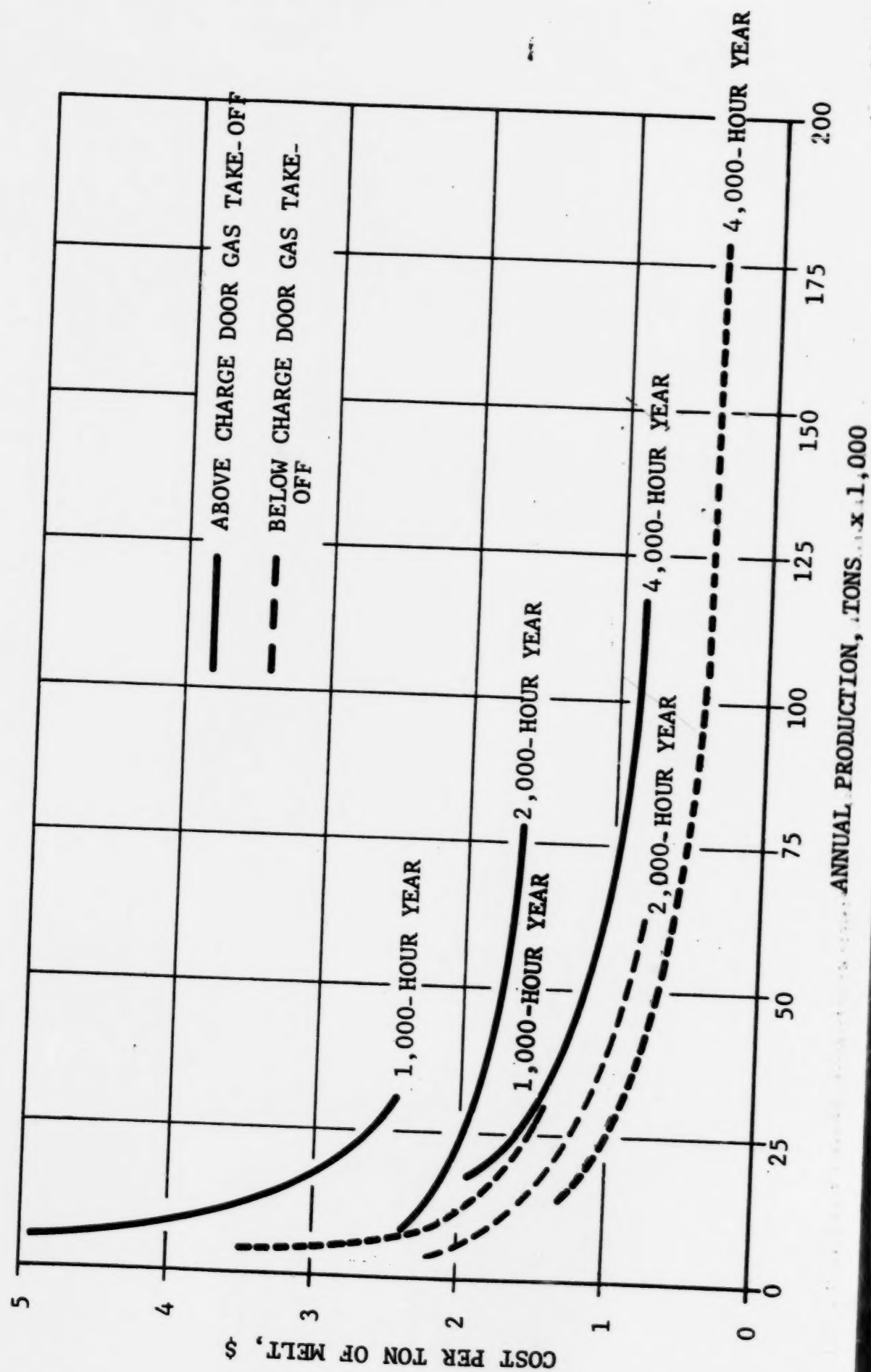
COMPARISON OF COST PER TON OF MELT
FOR HIGH ENERGY WET SCRUBBER ON
UNLINED CUPOLA AT DIFFERENT LEVELS
OF OPERATION 5/1 COKE RATIO



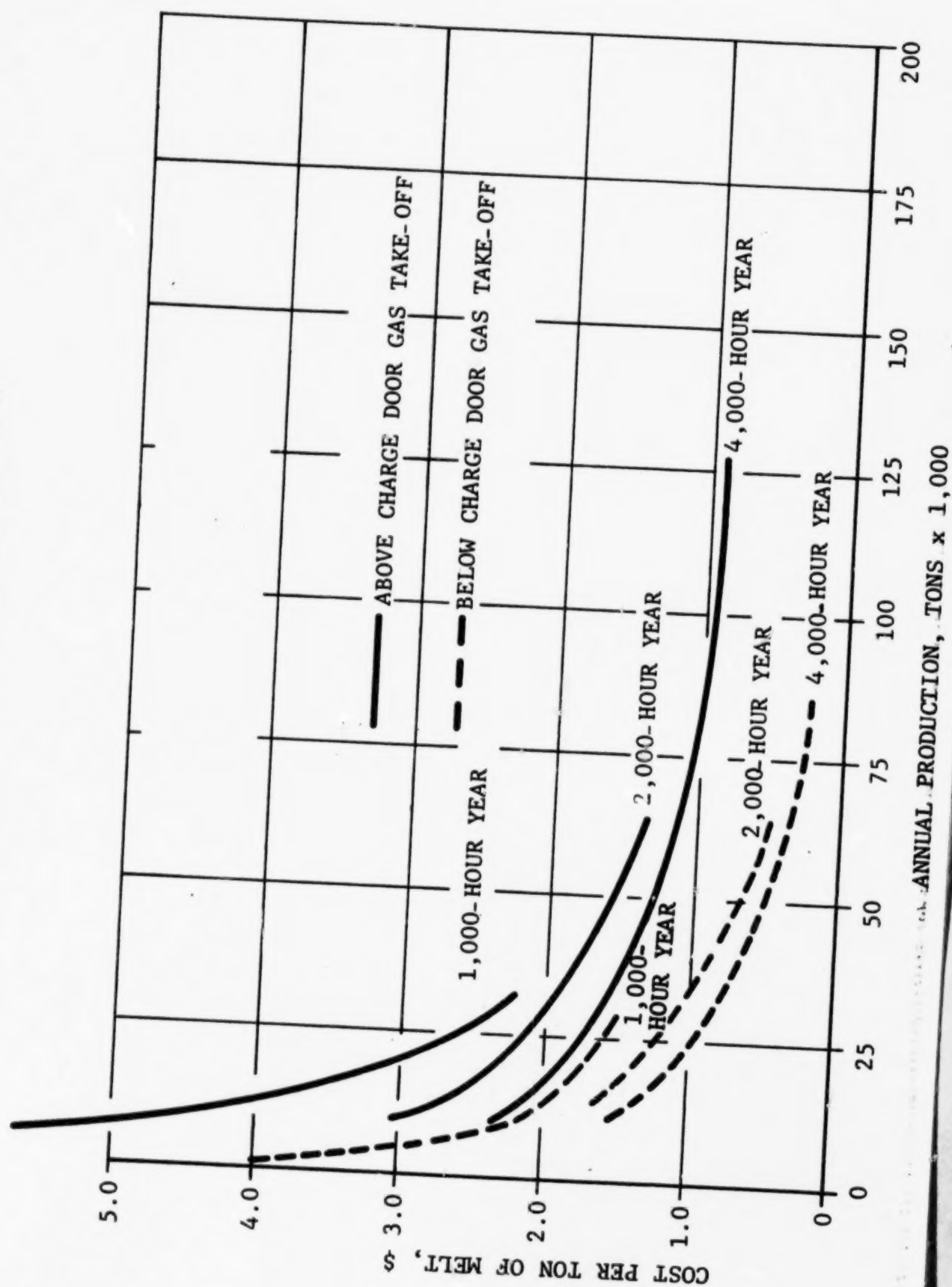
COMPARISON OF COST PER TON OF
MELT FOR HIGH ENERGY WET
SCRUBBER ON LINED CUPOLA
AT DIFFERENT LEVELS OF
OPERATION. 8/1 COKE RATIO



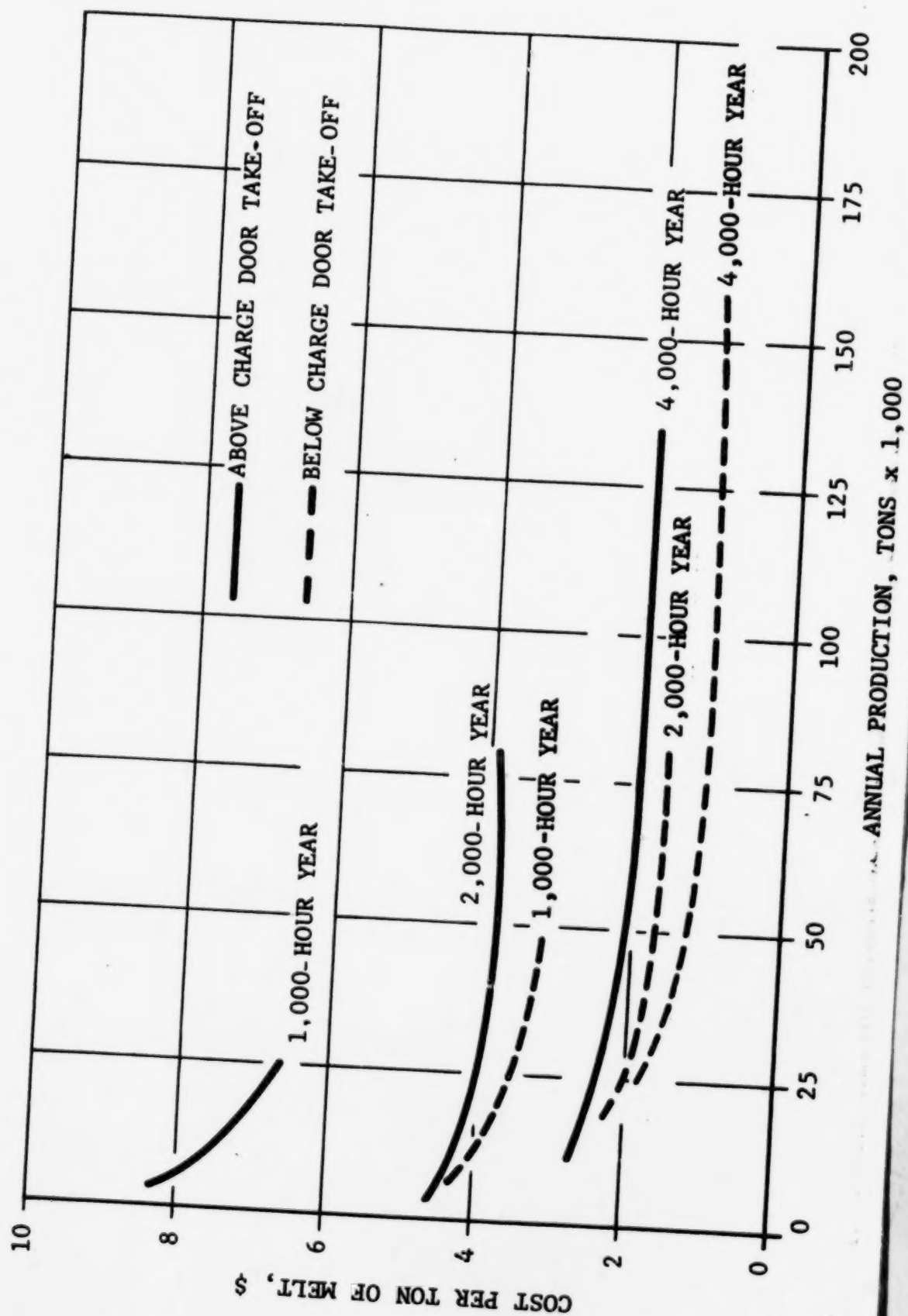
COMPARISON OF COST PER TON OF MELT FOR LOW ENERGY
WET SCRUBBER ON UNLINED CUPOLA AT DIFFERENT
LEVELS OF OPERATION 5/1 COKE RATIO

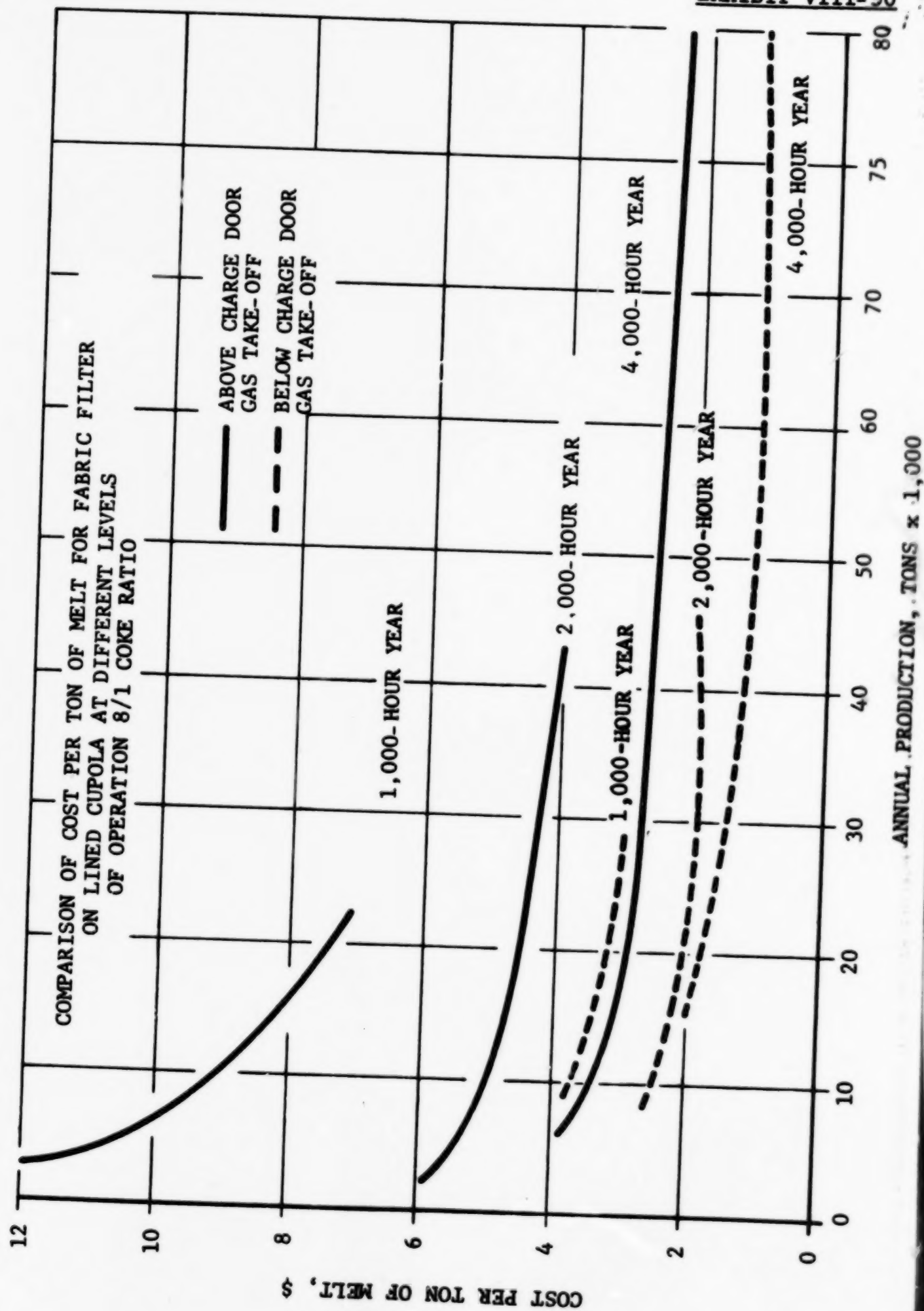


COMPARISON OF COST PER TON OF MELT
FOR LOW ENERGY WET SCRUBBER ON LINED
CUPOLA AT DIFFERENT LEVELS OF
OPERATION. 8/1 COKE RATIO



COMPARISON OF COST PER TON OF MELT
FOR FABRIC FILTER ON UNLINED CUPOLA
AT DIFFERENT LEVELS OF OPERATION
5/1 COKE RATIO





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SUMMARY OF CAPITAL COSTS TO PRODUCE IRON UN

<u>Alternate Number</u>	<u>Melt Rate Tons/Hour Operating Hours/Year</u>	5		
		<u>500</u>	<u>1,000</u>	<u>2,000</u>
1	<u>Cupola-Lined Cold Blast No Holding Furnace</u>			
	Buildings and Melting Department Equipment	\$ 395,000	\$ 395,000	\$ 497,000
	Emission Control Equipment (Fabric Filter)	<u>60,000</u>	<u>60,000</u>	<u>65,000</u>
	Total	\$ 455,000	\$ 455,000	\$ 562,000
	Emission Control as Percent of Total Cost	13.2%	13.2%	11.6%
2	<u>Cupola-Hot Blast-Induction Holding Furnace</u>			
	Buildings and Melting Department Equipment			\$ 507,000
	Emission Control Equipment (Wet Scrubber)			<u>70,000</u>
	Total			\$ 577,000
	Emission Control As Percent of Total Cost			12.1%
3	<u>Electric Arc-Induction Holding Furnace</u>			
	Buildings and Melting Department Equipment	\$ 826,000	\$ 826,000	\$ 826,000
	Emission Control Equipment (Fabric Filter)	<u>120,000</u>	<u>120,000</u>	<u>120,000</u>
	Total	\$ 946,000	\$ 946,000	\$ 946,000
	Emission Control as Percent of Total Cost	12.7%	12.7%	12.7%
4	<u>Coreless Induction-No Holding Furnace</u>			
	Buildings and Melting Department Equipment	\$ 813,000	\$ 813,000	\$ 813,000
	Emission Control Equipment (Afterburner)	<u>5,000</u>	<u>5,000</u>	<u>5,000</u>
	Total	\$ 818,000	\$ 818,000	\$ 818,000
	Emission Control as Percent of Total Cost	0.6%	0.6%	0.6%

Note: The assumptions made in the development of these figures are included in the te

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PRODUCE IRON UNDER VARIOUS PRODUCTION AND OPERATING CONDITIONS

	5		15			30		50	
	2,000	4,000	1,000	2,000	4,000	2,000	4,000	2,000	4,000
000	\$ 497,000		\$1,012,000	\$1,221,000	\$1,221,000	\$2,099,000	\$2,099,000	\$2,869,000	\$2,869,000
000	<u>65,000</u>		<u>210,000</u>	<u>220,000</u>	<u>220,000</u>	<u>440,000</u>	<u>440,000</u>	<u>690,000</u>	<u>690,000</u>
000	\$ 562,000		\$1,222,000	\$1,441,000	\$1,441,000	\$2,539,000	\$2,539,000	\$3,559,000	\$3,559,000
2%	11.6%		17.2%	15.3%	15.3%	17.3%	17.3%	19.4%	19.4%
	\$ 507,000	\$ 507,000		\$1,329,000	\$1,329,000	\$2,159,000	\$2,159,000	\$3,244,000	\$3,244,000
	<u>70,000</u>	<u>70,000</u>		<u>190,000</u>	<u>190,000</u>	<u>390,000</u>	<u>390,000</u>	<u>630,000</u>	<u>630,000</u>
	\$ 577,000	\$ 577,000		\$1,519,000	\$1,519,000	\$2,549,000	\$2,549,000	\$3,874,000	\$3,874,000
	12.1%	12.1%		12.5%	12.5%	15.3%	15.3%	16.3%	16.3%
000	\$ 826,000		\$2,352,000	\$2,352,000	\$2,352,000	\$3,765,000	\$3,765,000	\$5,174,000	\$5,174,000
000	<u>120,000</u>		<u>163,000</u>	<u>163,000</u>	<u>163,000</u>	<u>245,000</u>	<u>245,000</u>	<u>326,000</u>	<u>326,000</u>
000	\$ 946,000		\$2,515,000	\$2,515,000	\$2,515,000	\$4,010,000	\$4,010,000	\$5,500,000	\$5,500,000
7%	12.7%		6.5%	6.5%	6.5%	6.1%	6.1%	5.9%	5.9%
000	\$ 813,000		\$1,670,000	\$1,670,000	\$1,670,000	\$2,963,000	\$2,963,000	\$4,039,000	\$4,039,000
000	<u>5,000</u>		<u>10,000</u>	<u>10,000</u>	<u>10,000</u>	<u>15,000</u>	<u>15,000</u>	<u>19,000</u>	<u>19,000</u>
000	\$ 818,000		\$1,680,000	\$1,680,000	\$1,680,000	\$2,978,000	\$2,978,000	\$4,058,000	\$4,058,000
5%	0.6%		0.6%	0.6%	0.6%	0.5%	0.5%	0.5%	0.5%

included in the text discussion.

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SUMMARY OF OPERATING COSTS FOR PRODUCING IRON UNDER VARIOUS PRO

Alternate Number		Melt Rate Tons/Hour Operating Hours/Year	5			
			500	1,000	2,000	4,000
1	Cold Blast, Lined Cupola Without Holding Furnace Using Fabric Filter Collector					
	<u>Costs Per Ton</u>					
	Direct Material Conversion Cost		\$ 51.09 65.84	\$ 51.09 44.90	\$ 51.09 35.47	
	Subtotal		\$116.93	\$ 95.99	\$ 86.56	
	Emission Control		10.00	6.00	3.50	
	Total		\$126.93	\$101.99	\$ 90.06	
	Emission Control as Percent of Total		7.9%	5.9%	3.9%	
2	Hot Blast, Water-Cooled, Unlined Cupola with Channel Induction Holding Furnace Using High Energy Wet Scrubber					
	<u>Costs Per Ton</u>					
	Direct Material Conversion Cost				\$ 47.14 38.04	\$ 47.14 29.48
	Subtotal				\$ 85.18	\$ 76.62
	Emission Control				3.50	2.50
	Total				\$ 88.68	\$ 79.12
	Emission Control as Percent of Total				3.9%	3.2%
3	Electric Arc Furnace with Channel Induction Holding Furnace Using Fabric Filter Collector					
	<u>Costs Per Ton</u>					
	Direct Material Conversion Cost		\$ 44.69 143.72	\$ 44.69 84.93	\$ 44.69 55.09	\$ 44.69 71.14
	Subtotal		\$188.41	\$129.64	\$ 99.78	\$111.23
	Emission Control		22.40	12.40	6.50	3.50
	Total		\$210.81	\$142.04	\$106.28	\$114.73
	Emission Control as Percent of Total		10.6%	8.7%	6.1%	3.2%
4	Coreless Induction Furnace with Charge Preheater, Without Holding Furnace, Without Emission Control Except on Preheater					
	<u>Costs Per Ton</u>					
	Direct Material Conversion Cost		\$ 47.06 134.14	\$ 47.06 80.47	\$ 47.06 53.77	\$ 47.06 51.14
	Subtotal		\$181.20	\$127.53	\$100.83	\$ 98.28
	Emission Control		.46	.27	.17	.17
	Total		\$181.66	\$127.80	\$101.00	\$ 98.45
	Emission Control as Percent of Total		.3%	.2%	.2%	.2%

Note: The assumptions made in the development of these figures are included in the text discussion.

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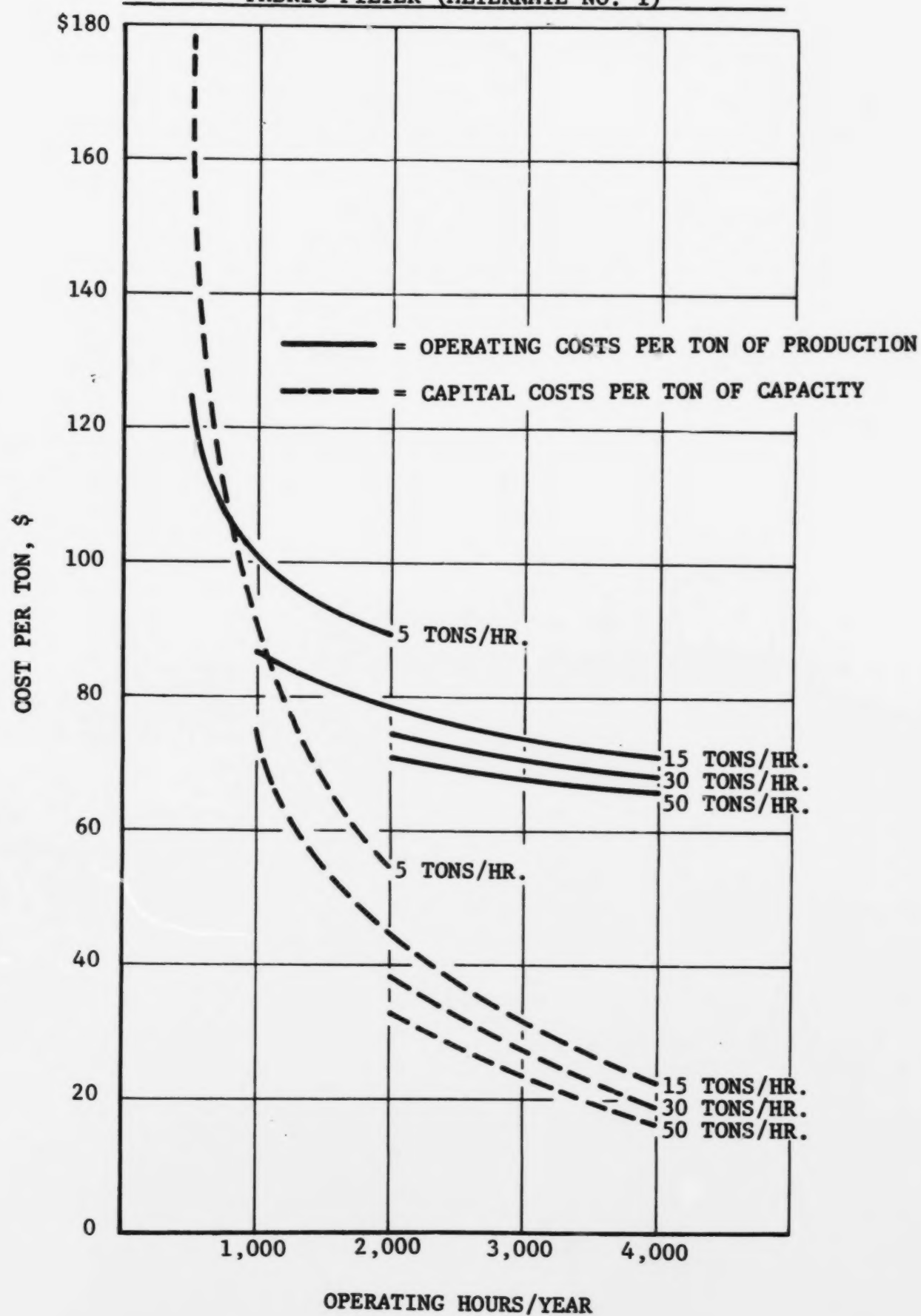
PRODUCING IRON UNDER VARIOUS PRODUCTION AND OPERATING CONDITIONS

	5		15			30		50	
	2,000	4,000	1,000	2,000	4,000	2,000	4,000	2,000	4,000
9	\$ 51.09		\$ 51.09	\$ 51.09	\$ 51.09	\$ 51.09	\$ 51.09	\$ 51.09	\$ 51.09
0	<u>35.47</u>		<u>33.22</u>	<u>25.70</u>	<u>19.56</u>	<u>21.92</u>	<u>16.40</u>	<u>18.55</u>	<u>14.16</u>
9	\$ 86.56		\$ 84.31	\$ 76.79	\$ 70.65	\$ 73.01	\$ 67.49	\$ 69.64	\$ 65.25
0	<u>3.50</u>		<u>4.00</u>	<u>2.33</u>	<u>1.33</u>	<u>2.33</u>	<u>1.33</u>	<u>1.80</u>	<u>1.00</u>
9	\$ 90.06		\$ 88.31	\$ 79.12	\$ 71.98	\$ 75.34	\$ 68.82	\$ 71.44	\$ 66.25
%	3.9%		4.5%	2.9%	1.9%	3.1%	1.9%	2.5%	1.5%
	\$ 47.14	\$ 47.14		\$ 47.14	\$ 47.14	\$ 47.14	\$ 47.14	\$ 47.14	\$ 47.14
	<u>38.04</u>	<u>29.48</u>		<u>26.51</u>	<u>19.22</u>	<u>21.71</u>	<u>16.05</u>	<u>18.83</u>	<u>14.00</u>
	\$ 85.18	\$ 76.62		\$ 73.65	\$ 66.36	\$ 68.85	\$ 63.19	\$ 65.97	\$ 61.14
	<u>3.50</u>	<u>2.50</u>		<u>2.00</u>	<u>1.25</u>	<u>1.83</u>	<u>1.17</u>	<u>1.65</u>	<u>.98</u>
	\$ 88.68	\$ 79.12		\$ 75.65	\$ 67.61	\$ 70.68	\$ 65.36	\$ 67.62	\$ 62.12
	3.9%	3.2%		2.6%	1.8%	2.6%	1.8%	2.4%	1.6%
9	\$ 44.69		\$ 44.69	\$ 44.69	\$ 44.69	\$ 44.69	\$ 44.69	\$ 44.69	\$ 44.69
5	<u>55.09</u>		<u>74.78</u>	<u>47.94</u>	<u>33.33</u>	<u>41.44</u>	<u>29.47</u>	<u>37.14</u>	<u>26.79</u>
4	\$ 99.78		\$ 119.47	\$ 92.63	\$ 78.02	\$ 86.13	\$ 74.16	\$ 81.83	\$ 71.48
0	<u>6.50</u>		<u>5.47</u>	<u>3.27</u>	<u>2.13</u>	<u>2.45</u>	<u>1.60</u>	<u>1.96</u>	<u>1.28</u>
4	\$ 106.28		\$ 124.94	\$ 95.90	\$ 80.15	\$ 88.58	\$ 75.76	\$ 83.79	\$ 72.76
%	6.1%		4.4%	3.4%	2.7%	2.8%	2.1%	2.3%	1.8%
6	\$ 47.06		\$ 47.06	\$ 47.06	\$ 47.06	\$ 47.06	\$ 47.06	\$ 47.06	\$ 47.06
7	<u>53.77</u>		<u>51.01</u>	<u>35.12</u>	<u>26.52</u>	<u>33.05</u>	<u>24.12</u>	<u>28.81</u>	<u>21.62</u>
3	\$ 100.83		\$ 98.07	\$ 82.18	\$ 73.58	\$ 80.11	\$ 71.18	\$ 75.87	\$ 68.68
7	<u>.17</u>		<u>.20</u>	<u>.14</u>	<u>.11</u>	<u>.12</u>	<u>.10</u>	<u>.11</u>	<u>.09</u>
0	\$ 101.00		\$ 98.27	\$ 82.32	\$ 73.69	\$ 80.23	\$ 71.28	\$ 75.98	\$ 68.77
%	.2%		.2%	.2%	.2%	.2%	.1%	.1%	.1%

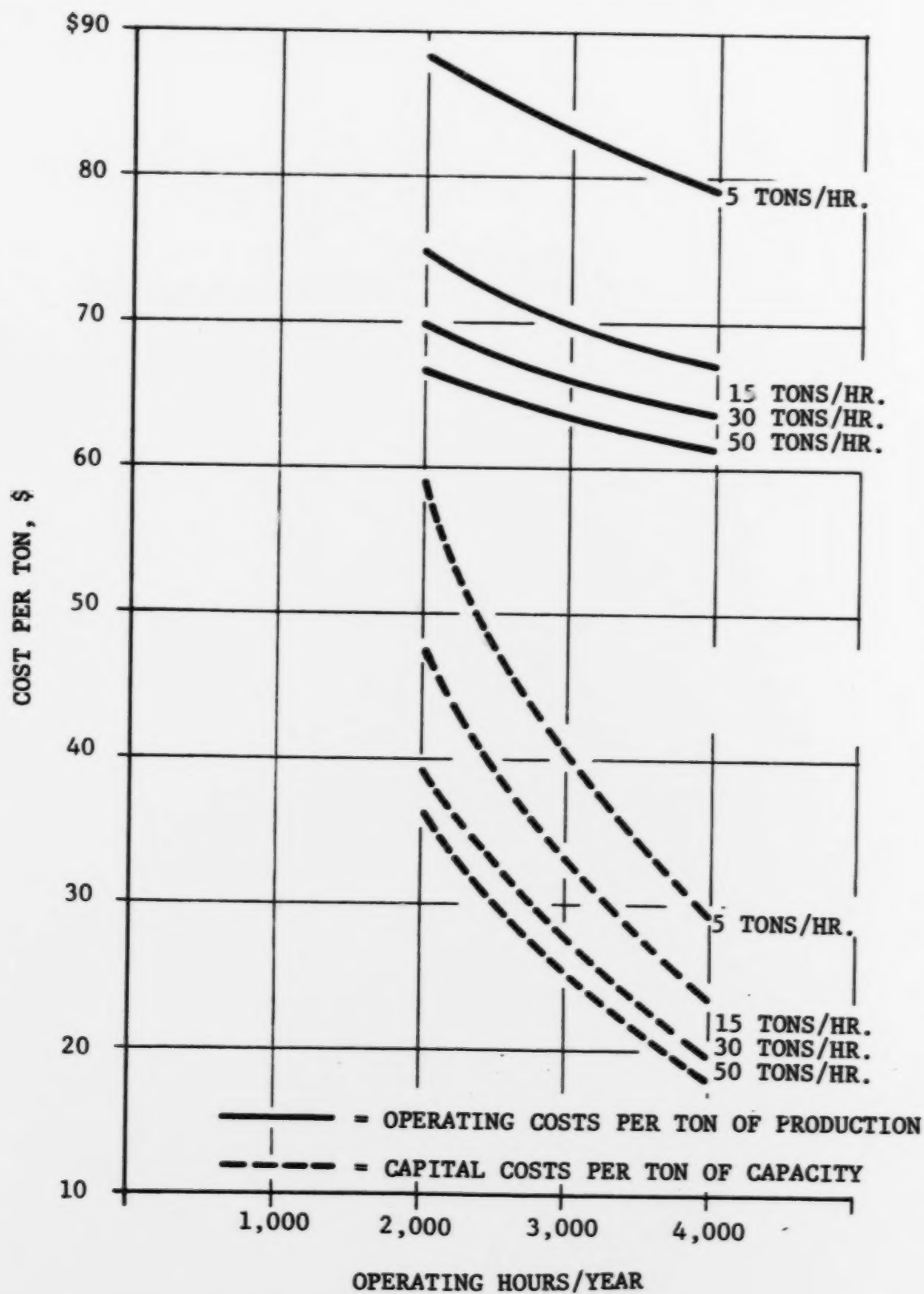
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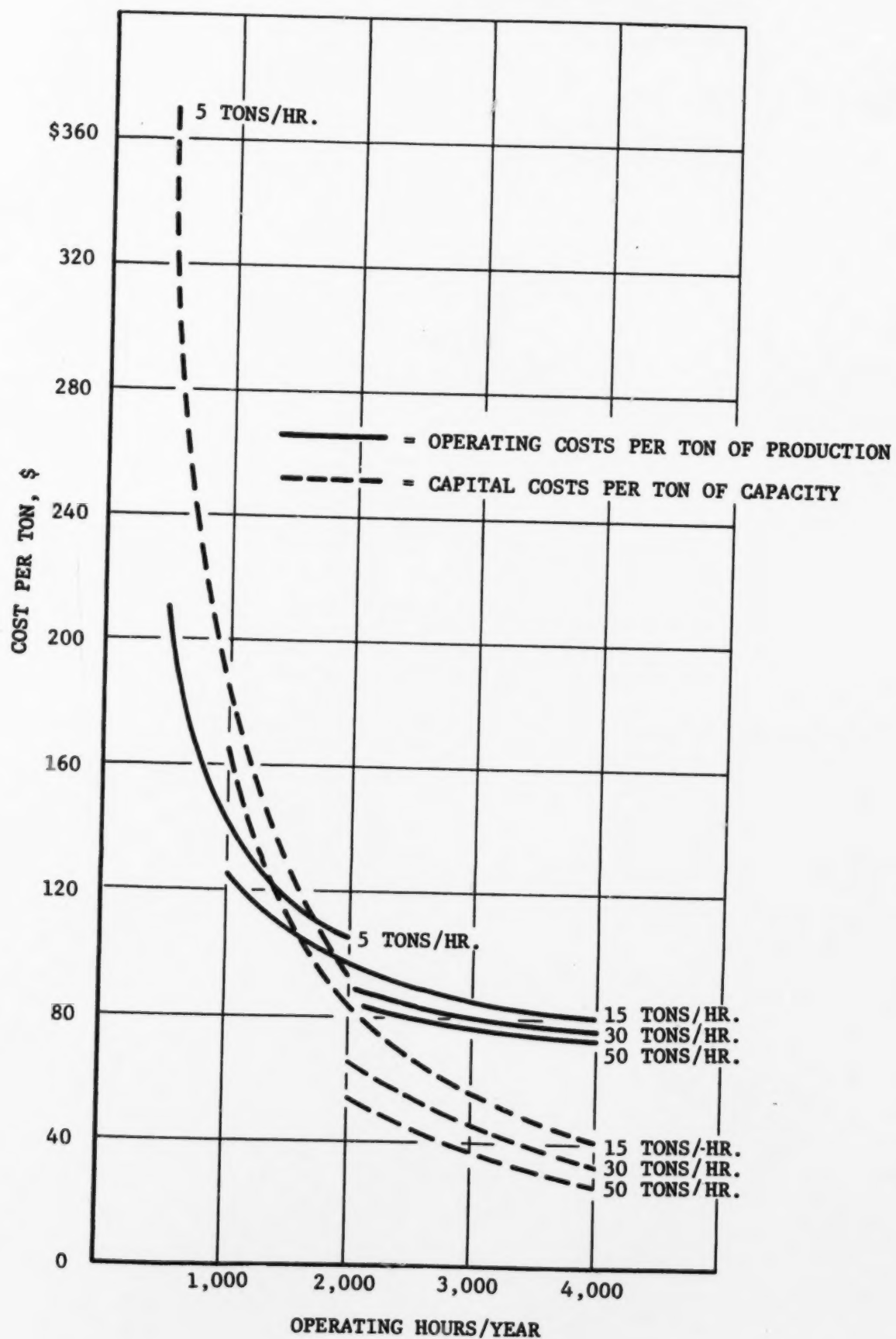
CAPITAL AND OPERATING COSTS PER TON VS. OPERATING
HOURS PER YEAR FOR COLD BLAST CUPOLA WITH
FABRIC FILTER (ALTERNATE NO. 1)



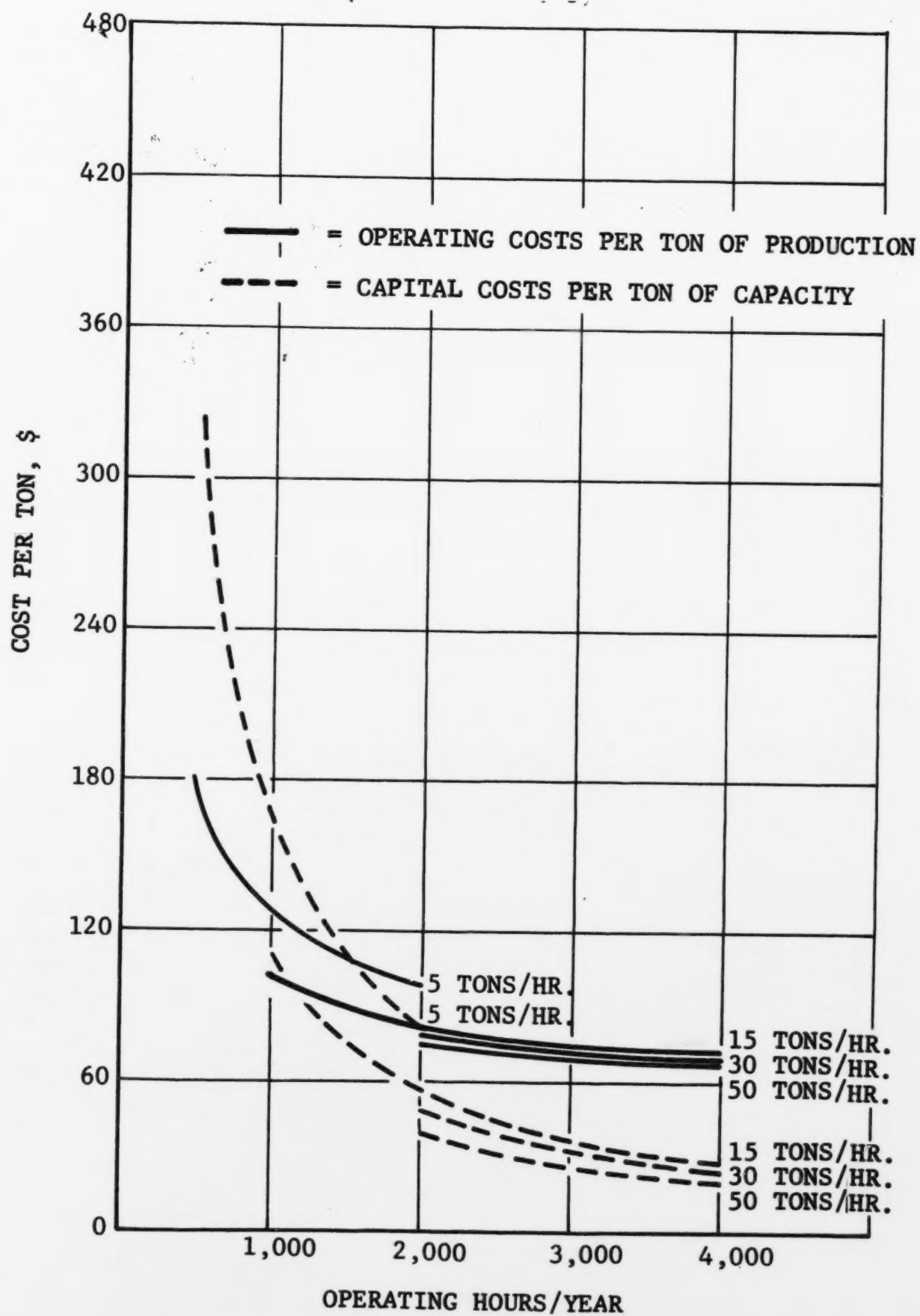
CAPITAL AND OPERATING COSTS PER TON VS. OPERATING
HOURS PER YEAR FOR HOT BLAST CUPOLA WITH
WET SCRUBBER (ALTERNATE NO. 2)



CAPITAL AND OPERATING COSTS PER TON VS. OPERATING
HOURS PER YEAR FOR ELECTRIC ARC FURNACE WITH
FABRIC FILTER (ALTERNATE NO. 3)



CAPITAL AND OPERATING COSTS PER TON VS. OPERATING
HOURS PER YEAR FOR CORELESS INDUCTION FURNACE
WITH AFTERBURNER ON PREHEATER (ALTERNATE NO. 4)



**MODIFICATIONS TO CUPOLA MELTING
PRACTICES TO REDUCE EMISSIONS**

Modification	Effect of Modification	Decrease in Emissions	Equipment Percent	Savings Operation	Total Annual Percent	Cost of Modification/Ton Metal Melted
<u>Decrease Stack Gas Volume</u>						
1. Decrease area of charging door and use vibrating feeder or chute.	Decrease air infiltration up to 85%. Decrease volume of gas to be cleaned up to 60%.	None	7%	-	33%	
2. Locate gas take-off below top of charge	Decrease total gas to be cleaned up to 74%	None	70%	-	60%	
3. Locate gas take-off at charging door	Decrease total gas volume 45%	None	-	-	57%	
<u>Decrease Coke Charge</u>						
4. Hot blast	Reduce coke requirement by heating blast air using natural gas fuel.	Moderate - Estimated to be -4% for constant melting rate.		\$1.00 per million BTU		
5. Oxygen enrichment	Add O ₂ to blast air to increase O ₂ content of blast from 21% to 25% permitting coke reduction.	Moderate - Estimated to be 5% to 10% for constant melting rate		\$1.25/ton of metal melted		
6. Natural gas injection	Inject natural gas and air in stoichiometric ratio to replace up to 40% of coke	Moderate - 15%		\$1.22/ton for 30% coke replacement \$2.01/ton for 40% coke replacement		
<u>Preparation of Charge Materials</u>						
7. Screen coke and limestone	Remove coke breeze and limestone dust from charge	Depends upon degradation of coke and limestone. Estimated range of decrease 5%-20% consisting principally of +44 micron particles.	Nominal cost		Nominal Savings	
8. Shot blast foundry returns	Removes embedded molding and core sand	Depends upon amount of sand on returns. Estimated range of decrease 2%-8%.				\$2.00-\$2.50/ton
9. Incineration or detergent washing broken motor blocks or shredded automotive steel scrap	Remove oil, grease and other combustibles	Depends upon amount of combustibles in scrap. Estimated range of decrease 2%-25%	-	-	-	\$3.50 - \$4.00
10. Remove nonferrous contaminants	Reduces nonferrous metallic oxides in cupola emissions	Depends upon amount of nonferrous material in scrap. Estimated range of decrease 1%-2%	-	-	-	

EXHIBIT IX-1

INVENTORY OF IRON FOUNDRY EMISSIONS
FROM MELTING OPERATIONS, 1969

Region	Castings Production Tons (1)	Molten Iron Production Tons (1)	Total Particulate Emissions Generated, Tons (3)	Carbon Monoxide Generated, Tons (3)	Particulate Emissions Emitted, Tons (4)	Carbon Monoxide Emitted, Tons (5)
<u>New England</u>	235,000	362,000	3,800	49,000	2,800	24,500
Maine						
New Hampshire						
Vermont						
Massachusetts						
Rhode Island						
Connecticut						
<u>Middle Atlantic</u>	3,501,000	5,143,000	51,000	594,000	38,000	297,000
New York						
New Jersey						
Pennsylvania						
<u>East N. Central</u>	8,225,000	12,613,000	126,000	1,541,000	94,500	770,500
Ohio						
Indiana						
Illinois						
Michigan						
Wisconsin						
<u>West N. Central</u>	607,000	881,000	9,100	115,000	6,800	57,500
Minnesota						
Iowa						
Missouri						
Nebraska						
Kansas						
N. Dakota						
S. Dakota						
<u>South Atlantic</u>	473,000	662,000	6,800	88,000	5,100	44,000
Delaware						
Maryland						
Virginia						
W. Virginia						
N. Carolina						
S. Carolina						
Georgia						
Florida						
<u>East S. Central</u>	2,300,000	2,887,000	27,700	304,000	20,800	152,000
Kentucky						
Mississippi						
Alabama						
Tennessee						
<u>West S. Central</u>	531,000	748,000	7,700	100,000	5,800	50,000
Arkansas						
Louisiana						
Oklahoma						
Texas						
<u>Mountain</u>	243,000	332,000	3,300	38,000	2,500	19,000
Montana						
Colorado						
Arizona						
Nevada (2)						
Idaho						
New Mexico (2)						
Wyoming (2)						
<u>Pacific</u>	499,000	739,000	7,600	95,000	5,700	47,500
Washington						
Oregon						
California						
Hawaii						
Alaska						
Total	16,614,000	24,367,000	243,000	2,924,000	182,000	1,462,000

- Notes: (1) Castings and molten iron production quantities from cupolas and electric arc furnaces only.
- (2) No iron foundries are located in Nevada, New Mexico, and Wyoming.
- (3) Particulate emissions and carbon monoxide generated are the estimated maximum produced.
- (4) Particulate emissions emitted are estimated at 75% of maximum produced, with an average 25% being collected.
- (5) Carbon monoxide emitted is estimated at 50% being burned and 50% released to the atmosphere.

**INVENTORY OF IRON FOUNDRY EMISSIONS
FROM NON-MELTING OPERATIONS, 1969**

<u>Region</u>	<u>Castings Production Tons</u>	<u>Molten Iron Production Tons</u>	<u>Total Particulate Emissions Generated Tons</u>	<u>Particulate Emissions Emitted Tons</u>
<u>New England</u>	239,000	368,000	21,000	1,100
Maine				
New Hampshire				
Vermont				
Massachusetts				
Connecticut				
<u>Middle Atlantic</u>	3,643,000	5,603,000	319,400	16,200
New York				
New Jersey				
Pennsylvania				
<u>East North Central</u>	8,453,000	13,001,000	741,100	37,700
Ohio				
Indiana				
Illinois				
Michigan				
Wisconsin				
<u>West North Central</u>	677,000	1,041,000	59,300	3,000
Minnesota				
Iowa				
Missouri				
Nebraska				
North Dakota				
South Dakota				
<u>South Atlantic</u>	485,000	746,000	42,500	2,200
Delaware				
Maryland				
Virginia				
West Virginia				
North Carolina				
South Carolina				
Georgia				
Florida				
<u>East South Central</u>	2,327,000	3,579,000	204,000	10,400
Kentucky				
Mississippi				
Alabama				
Tennessee				
<u>West South Central</u>	551,000	847,000	48,300	2,500
Arkansas				
Louisiana				
Oklahoma				
Texas				
<u>Mountain</u>	249,000	383,000	21,800	1,100
Montana				
Colorado				
Arizona				
Nevada (1)				
Idaho				
New Mexico (1)				
Wyoming (1)				
<u>Pacific</u>	531,000	817,000	46,600	2,400
Washington				
Oregon				
California				
Hawaii				
Alaska				
<u>Total</u>	<u>17,155,000</u>	<u>26,385,000</u>	<u>1,504,000</u>	<u>76,600</u>

Note: (1) No iron foundries are located in Nevada, New Mexico, and Wyoming.

RATING CODE
IRON FOUNDRY EMISSION CONTROL

EXHIBIT XI-3
Page 1 of 2

CLASSIFICATION	RATING NUMBER			
	1-5	6-10	11-15	16-20
<u>Amount of Emissions</u> Comparison of emission rates from all sources.	Low	Moderate	High	Very High
<u>Particle Size</u> Based on particle size distribution. Maximum diameter of finest 20% by weight.	Coarse	Medium	Fine	Very Fine
<u>Difficulty of Capture</u> Based on degree of confinement of emissions at source.	Easy	Moderate	Difficult	Extremely Difficult
<u>Difficulty of Separation</u> Comparison of particle size distribution and other characteristics of emissions affecting difficulty of separation.	Easy	Moderate	Difficult	Extremely Difficult
<u>Cost of Control Systems</u> Relative cost of separation equipment only, as affected by type of system and pressure drop.	Low	Medium	High	Extremely High
<u>Cost of Auxiliary Equipment</u> Based on complexity of ductwork, cost of motors, blowers and other auxiliary equipment.	Low	Medium	High	Extremely High
<u>Availability of Control Equipment</u> Based on whether equipment is standard and mass-produced, requires detailed engineering, or complete design engineering.	Readily Available	Available	Difficult to Find	Experimental or Pilot Plant Systems Only
<u>Capability of Control Equipment</u> Ability of existing control devices to perform satisfactorily.	Very Capable	Moderately Capable	Capable	Not Capable
<u>Priority Rating-</u>				
<u>Priority</u>	7-80 Low	80-110 Medium	110-160 High	

PRIORITY RATING CHART
IRON FOUNDRY EMISSION CONTROL

Department	Operation	Amount of Emission	Particle Size	Difficulty of Capture	Difficulty of Separation	Cost Cont Equip
Scrapyards	Raw material handling and storage	1	5	15	5	
	Charge makeup	1	5	15	5	
Melting	Cupola	15	15	10	20	20
	Direct Electric Arc	10	20	5	15	15
	Induction	1	10	5	15	0
	Reverberatory	1	10	5	15	0
	Charge Preheating	5	10	5	15	10
	Magnesium Treatment	5	18	5	20	10
Molding, Pouring & Shakeout	Molding	1	5	8	10	5
	Pouring	5	10	15	15	5
	Shakeout	20	10	10	10	5
Cleaning & Finishing	Abrasive Cleaning	15	7	4	5	5
	Grinding	2	3	3	5	5
	Annealing and Heat Treating	1	5	3	5	5
	Painting	3	5	6	8	5
Sand Conditioning	Dry Sand Handling	10	10	10	10	10
	Prepared Sand Handling	10	10	10	5	0
	Screening	10	10	5	5	10
	Mixing	15	10	5	5	10
	Drying and Reclamation	10	10	5	5	10
Core Department	Oil Sand Core Baking	10	20	5	5	5
	Shell and Cold Set Sand Curing	15	20	15	20	10
Pattern Shop	Wood Pattern Making	5	3	5	5	5
	Metal Pattern Making	5	5	5	5	5

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TY RATING CHART

DRY EMISSION CONTROL

Difficulty of Capture	Difficulty of Separation	Cost of Control Equipment	Cost of Auxiliary Equipment	Control Equipment Availability	Control Equipment Reliability	Total Priority Rating
15	5	5	5	5	5	46
15	5	5	5	5	5	46
10	20	20	20	10	10	120
5	15	15	10	10	10	95
5	15	0	0	5	5	41
5	15	0	0	5	5	41
5	15	10	5	5	10	65
5	20	10	5	10	10	83
8	10	5	7	5	5	46
15	15	5	15	5	5	75
10	10	5	5	5	5	70
4	5	5	5	5	5	51
3	5	5	5	5	5	33
3	5	5	5	5	5	34
6	8	5	5	5	5	42
10	10	10	10	5	5	70
10	5	0	10	5	5	55
5	5	10	5	5	5	55
5	5	10	5	5	5	60
5	5	10	5	5	5	55
5	5	5	10	10	10	75
15	20	10	15	10	15	120
5	5	5	5	5	5	38
5	5	5	5	5	5	40

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PROPOSED RESEARCH AND DEVELOPMENT

Number	Title	Description	Priorities	Estimated Cost
1	Stack Sampling Program	Controlled program of cupola stack emission sampling by research institute or university to determine effect on the quantity and type of emissions.	High level priority	\$150,000-\$200,000
2	Iron Oxide Formation	An extension of Project #1 to provide quantitative data on effect of variables on iron oxide formation in the cupola.	Medium level priority	\$50,000-\$75,000
3	Fine Oxide-Opacity Relationship	An extension of Project #1 to provide data on relationship between quantity of fine metallic oxides in cupola gases and opacity of stack plume.	Medium level priority	\$50,000-\$75,000
4	High Temperature Fabric	Development of fabric materials for fabric filters, which will be resistant to high temperatures and corrosive gases.	Medium level priority	\$75,000-\$100,000
5	Waste Heat Utilization	Development of means for efficient utilization of sensible heat and heat of combustion of cupola stack gases.	Medium level priority	\$100,000-\$150,000
6	Continuous Melting Furnace	Development of continuous iron melting furnace using oil or gas fuel or electric power for economical, low emission melting.	Medium level priority	\$200,000-\$300,000
7	Scrap Preparation	Development of economical, centralized scrap preparation facility to serve iron foundries.	Medium level priority	\$30,000-\$50,000
8	Core Binder Materials	Development of core binder materials with low level of acrid or noxious gas evolution during curing.	Medium level priority	\$100,000-\$150,000
9	Agglomeration of Fines	Development of sonic method of agglomeration of fine particles to make them easier to collect.	Low level priority	\$75,000-\$100,000
10	Waste Product Utilization	Development of uses for waste products from melting operations.	Low level priority	\$20,000-\$30,000
Total All Programs				<u>\$850,000-\$1,230,000</u>

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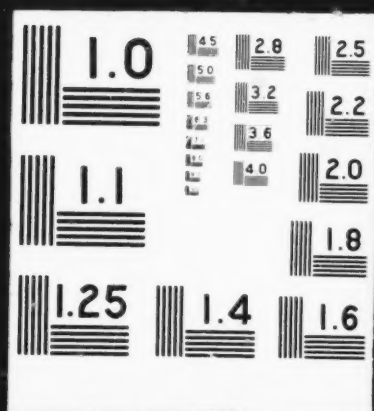
EXHIBIT XII-1

PROPOSED RESEARCH AND DEVELOPMENT PROJECTS

Activities	Estimated Cost	Known Research	Summarization
Level 1 Activity	\$150,000-\$200,000	None	Results of program will provide input to more accurately relate cupola operation and design variables to emissions, and thereby assist in developing solutions to emissions problems.
Level 2 Activity	\$50,000-\$75,000	None	Results of program will relate iron oxide formation in cupola to operating variables, and may lead to reduction in oxide formation.
Level 3 Activity	\$50,000-\$75,000	None	Results of program will provide more quantitative means for measuring cupola emissions levels by means of opacity tests.
Level 4 Activity	\$75,000-\$100,000	Brunswick Corp. and Applied Research Control Div. joint development program. NAPCA sponsored fiber glass and high temperature fabric filter studies.	New fabric materials will expand use of fabric filter collectors, will reduce costs of collection, and make them more reliable.
Level 5 Activity	\$100,000-\$150,000	Butler & Kutny system of using sand for gas cooling and air preheating. Holley, Kenney & Schoff with Majestic Iron Works-system for burning cupola gas and preheating air.	Development of an efficient and reliable waste heat recovery system will improve cupola economics and reduce coke consumption.
Level 6 Activity	\$200,000-\$300,000	Battelle Memorial Institute with Cooper Bessemer, fuel fired, shaft melting furnace. General Motors with Ajax Magnethermic, induction heated continuous melt furnace.	Development of an efficient, economical, low emission iron melting furnace will provide a means of replacing the cupola for iron melting.
Level 7 Activity	\$30,000-\$50,000	U.S. Bureau of Mines Study-dismantling junk autos to produce quality scrap.	Results of program will provide means for economical, efficient scrap cleaning and preparation to serve groups of foundries from centralized source.
Level 8 Activity	\$100,000-\$150,000	None reported-but manufacturers of core binder chemicals believed to be working on problem.	New binder materials needed to reduce odors and toxicity of gases produced during coremaking.
Level 9 Activity	\$75,000-\$100,000	None	Results of program will improve collection efficiency and reduce costs by eliminating or reducing quantity of fine particles.
Level 10 Activity	\$20,000-\$30,000	Zoller Castings Co.-use of cupola emissions for fertilizer. Swindell Dressler-use of steel plant wastes.	Development of uses for waste products will improve economics of dust collection and iron foundry operation.
	<u>\$850,000-\$1,230,000</u>		

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MODIFICATIONS TO CUPOLA MELTING
PRACTICES TO REDUCE EMISSIONS

Modification	Effect of Modification	Decrease in Emissions	Equipment Percent	Savings Operation	Total Annual Percent	Cost of Modification/Ton Metal Melted
<u>Decrease Stack Gas Volume</u>						
1. Decrease area of charging door and use vibrating feeder or chute.	Decrease air infiltration up to 85%. Decrease volume of gas to be cleaned up to 60%.	None	7%	-	33%	
2. Locate gas take-off below top of charge	Decrease total gas to be cleaned up to 74%	None	30%	-	40%	
3. Locate gas take-off at charging door	Decrease total gas volume 45%	None	-	-	43%	
<u>Decrease Coke Charge</u>						
4. Hot blast	Reduce coke requirement by heating blast air using natural gas fuel.	Moderate - Estimated to be -4% for constant melting rate.		\$1.00 per million BTU		
5. Oxygen enrichment	Add O ₂ to blast air to increase O ₂ content of blast from 21% to 25% permitting coke reduction.	Moderate - Estimated to be 5% to 10% for constant melting rate		\$1.25/ton of metal melted		
6. Natural gas injection	Inject natural gas and air in stoichiometric ratio to replace up to 40% of coke	Moderate - 15%		\$1.22/ton for 30% coke replacement \$2.01/ton for 40% coke replacement	Nominal Savings	
<u>Preparation of Charge Materials</u>						
7. Screen coke and limestone	Remove coke breeze and limestone dust from charge	Depends upon degradation of coke and limestone. Estimated range of decrease 5%-20% consisting principally of +44 micron particles.	Nominal cost			
8. Shot blast foundry returns	Removes embedded molding and core sand	Depends upon amount of sand on returns. Estimated range of decrease 2%-8%.				\$2.00-\$2.50/ton
9. Incineration or detergent washing broken motor blocks or shredded automotive steel scrap	Remove oil, grease and other combustibles	Depends upon amount of combustibles in scrap. Estimated range of decrease 2%-25%	-	-	-	\$3.50 - \$4.00
10. Remove nonferrous contaminants	Reduces nonferrous metallic oxides in cupola emissions	Depends upon amount of nonferrous material in scrap. Estimated range of decrease 1%-2%	-	-	-	

EXHIBIT IX-1
(Revised)